High Performance Transceiver for Sub 1-Ghz Applications

SPIRIT1

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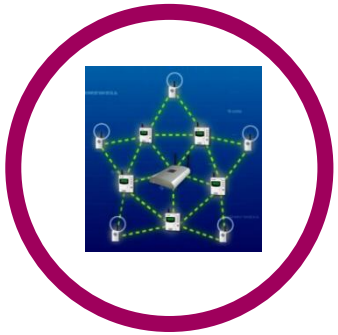
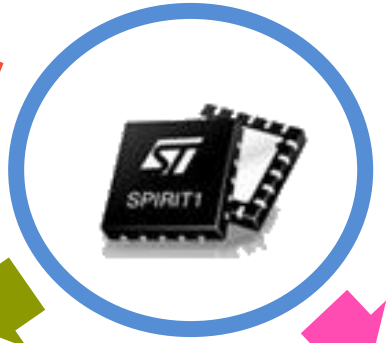
SPIRIT1 application focus

HOME/BUILDING AUTOMATION

SMART METERING



WIRELESS SENSOR NETWORKS



RM SYSTEMS

INDUSTRIAL MONITORING & CONTROL

Выделенные полосы радиочастот

Радиочастота	Основные технические характеристики (Выходная мощность, ЭИИМ* и др.)	Назначение	Регламентирующий документ
433,075-434,79 МГц	10 мВт (EN 300 220) (Рабочий цикл неограничен)	**Неспециализированные (любого назначения) устройства** – устройства малого радиуса общего применения, включая устройства дистанционного управления и передачи телеметрии, телеуправления, сигнализации, передачи данных и других подобных передач. Допускается использование маломощными радиостанциям и устройствами для обработки штрихкодов	Приложение 1 к решению ГКРЧ от 7 мая 2007 г. № 07-20-03-001
433,05- 434,79 МГц	5 мВт (Рабочий цикл < 10%)	**Устройства охранной радиосигнализации** – системы радиосигнализации, включающие системы общественной радиосигнализации и системы радиосигнализации для обеспечения безопасности	Приложение 3 к решению ГКРЧ от 7 мая 2007 г. № 07-20-03-001
868-868,2 МГц	10 мВт (Рабочий цикл < 10%)	**Устройства охранной радиосигнализации** – системы радиосигнализации, включающие системы общественной радиосигнализации и системы радиосигнализации для обеспечения безопасности	Приложение 3 к решению ГКРЧ от 7 мая 2007 г. № 07-20-03-001
868,7-869,2 МГц	25 мВт (EN 300 220)	**Неспециализированные (любого назначения) устройства** – устройства малого радиуса общего применения, включая устройства дистанционного управления и передачи телеметрии, телеуправления, сигнализации, передачи данных и других подобных передач.	Приложение 11 к решению ГКРЧ от 07.05.2007 № 07-20-03-001
863-865 МГц	10 мВт (EN 301 357) Рабочий цикл 100%	**Беспроводное аудиооборудование** – устройства малого радиуса действия, используемые для передачи данных между акустическими системами, наушниками, микрофонами и другими аудиоустройствами.	Приложение 14 к решению ГКРЧ от 07.05.2007 № 07-20-03-001
2400-2483,5 МГц	2,5 мВт (ЭИИМ)	**[Bluetooth Class 2]** Устройства с псевдослучайной перестройкой рабочей частоты (ППРЧ). Ширина канала не менее 1 МГц. Время пребывания (работы) на одной несущей, выбор которой осуществляется по псевдослучайному закону, не более 0,4 сек. Количество используемых каналов ППРЧ – 79	Приложение к решению ГКРЧ от 15 декабря 2009 г. № 09-05-09
2400-2483,5 МГц	100 мВт	**[Bluetooth Class 1]** Устройства с псевдослучайной перестройкой рабочей частоты (ППРЧ). Ширина канала не менее 1 МГц. Время пребывания (работы) на одной несущей, выбор которой осуществляется по псевдослучайному закону, не более 0,4 сек. Количество используемых каналов ППРЧ – 79. Допускается применение РЭС вне закрытых помещений только при высоте установки РЭС не более 10 м от поверхности Земли. Для целей сбора информации телеметрии в составе автоматизированных систем контроля и учета ресурсов или систем охраны допускается применение без ограничений по высоте установки РЭС.	Приложение к решению ГКРЧ от 15 декабря 2009 г. № 09-05-09
2400-2483,5 МГц	100 мВт (ЭИИМ), Максимальная спектральная плотность ЭИИМ не более 2 мВт/МГц	**[802.15.4/ZigBee и др.]** Устройства с прямым расширением спектра и другими видами модуляции.	Приложение к решению ГКРЧ от 15 декабря 2009 г. № 09-05-09
2400-2483,5 МГц	100 мВт (ЭИИМ), Максимальная спектральная плотность ЭИИМ не более 20 мВт/МГц	**[802.15.4/ZigBee и др.]** Устройства с прямым расширением спектра и другими видами модуляции. Допускается применение РЭС вне закрытых помещений только для целей сбора информации телеметрии в составе автоматизированных систем контроля и учета ресурсов или систем охраны	Приложение к решению ГКРЧ от 15 декабря 2009 г. № 09-05-09
2400-2483,5 МГц	100 мВт (ЭИИМ)	Устройства с псевдослучайной перестройкой рабочей частоты (ППРЧ). Ширина канала не менее 1 МГц. Время пребывания (работы) на одной несущей, выбор которой осуществляется по псевдослучайному закону, не более 0,4 сек. Количество используемых каналов ППРЧ – не менее 15. Для применения внутри закрытых помещений.	Приложение к решению ГКРЧ от 15 декабря 2009 г. № 09-05-09
2400-2483,5 МГц	100 мВт (ЭИИМ), Максимальная спектральная плотность ЭИИМ не более 10 мВт/МГц	Устройства с прямым расширением спектра и другими видами модуляции. Для применения внутри закрытых помещений.	Приложение к решению ГКРЧ от 15 декабря 2009 г. № 09-05-09

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SPIRIT1: Best in class transceiver

Operation Lifetime Doubles in Smart Meters and Other Wireless Sensor Node Applications with New Wireless Transceiver from STMicroelectronics

ST's SPIRIT1 wireless transceiver cuts power budget by 50% over competing devices

Geneva, April 26, 2012 - STMicroelectronics (NYSE:STM), a global semiconductor leader serving customers across the spectrum of electronics applications and a world leader in smart metering and industrial applications, today introduced a high-performance, ultra-low-power wireless transceiver for Automatic Meter Infrastructure and other wireless sensor node applications, such as alarm and security systems, home and building automation, and industrial monitoring and control. ST's **SPIRIT1** transceiver combines excellent receiver sensitivity with unbeatable current consumption, delivering 50% power reduction over existing solutions in the market.

Replacing traditional electromechanical meters, 'smart' electronic meters bring many advantages for utility providers and consumers alike. Features like full remote control, power peak and consumption analysis, anti-tampering mechanisms, fault alert, and time-variable tariffs, help make both the supply and usage of electricity, gas or water more efficient and economical.

ENTERING THE MARKET WITH BEST IN CLASS SOLUTION

Cuts power budget up to 30% over competing devices

Design focused on Power Savings

- RX 9 mA
- TX 21 mA (+11 dBm)
- Shutdown 2.5 nA

Excellent Sensitivity -120 dBm

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SPIRIT1: Description

- **Frequency bands: 169, 315, 433, 868, 915, 920 MHz**
- **Configurable data rate from 1 to 500 kbps**
- **SPI interface**
- **Supply voltage: 1.8 V to 3.6V**
- **Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, ASK**
- **Suitable for Systems targeting compliance**
  - Wireless MBUS standard
  - ETSI EN 300 220, FCC CFR47 Part 15, ARIB STD-67

QFN20 4x4
(thickness 0.9mm)

Available NOW

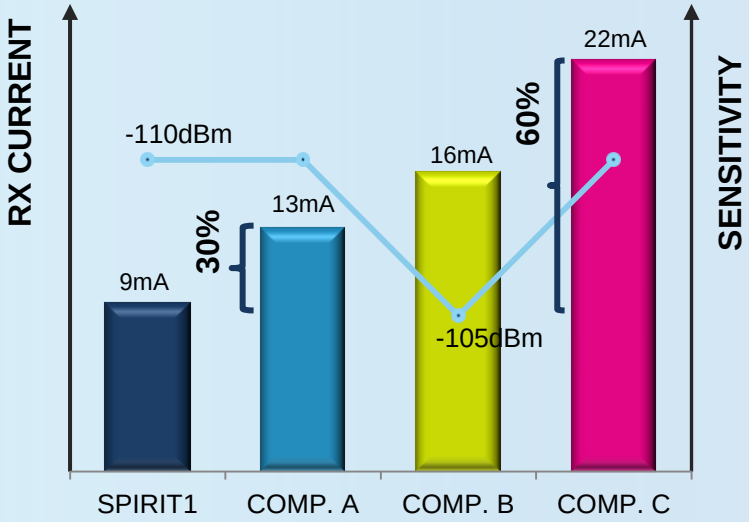
M-Bus wireless

SPIRIT1: Key Features

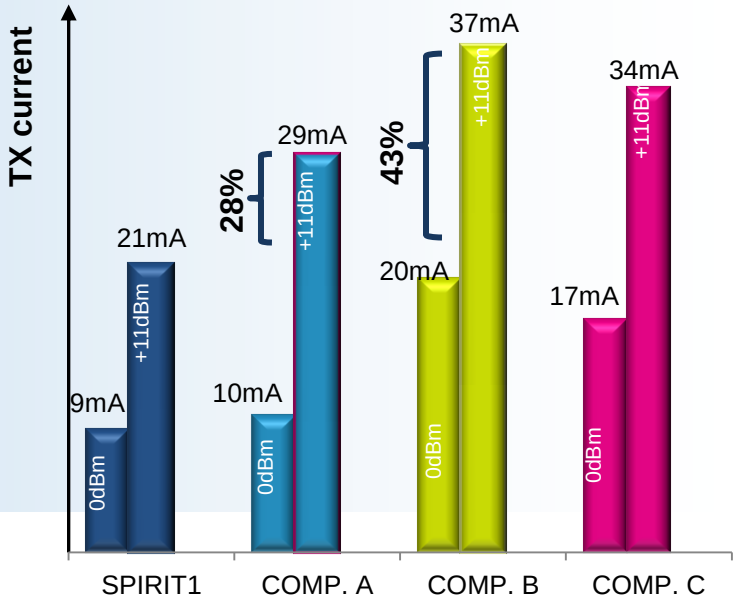
- **Output Power: -36 dBm to +11 dBm, in 0.5 dB steps**
- **Excellent receiver sensitivity: - 120 dBm** (1.2 kbps – 169MHz)
- **Integrated SMPS allows very low power consumption**

RX	9 mA	SPI on, XTAL on, Synth on
TX	21 mA	SPI on, XTAL on, Synth on
Ready	400 uA	SPI on, XTAL on
Sleep	950 nA	SPI on, register retention, RC oscillator
Standby Mode	650 nA	SPI on, register retention
Shutdown Mode	2.5 nA	Everything OFF

SPIRIT1: Operation lifetime increases



- **RX Current consumption cut >30%**
- Sensitivity performances are not sacrificed



TX Current consumption cut >28% @ max o/p power

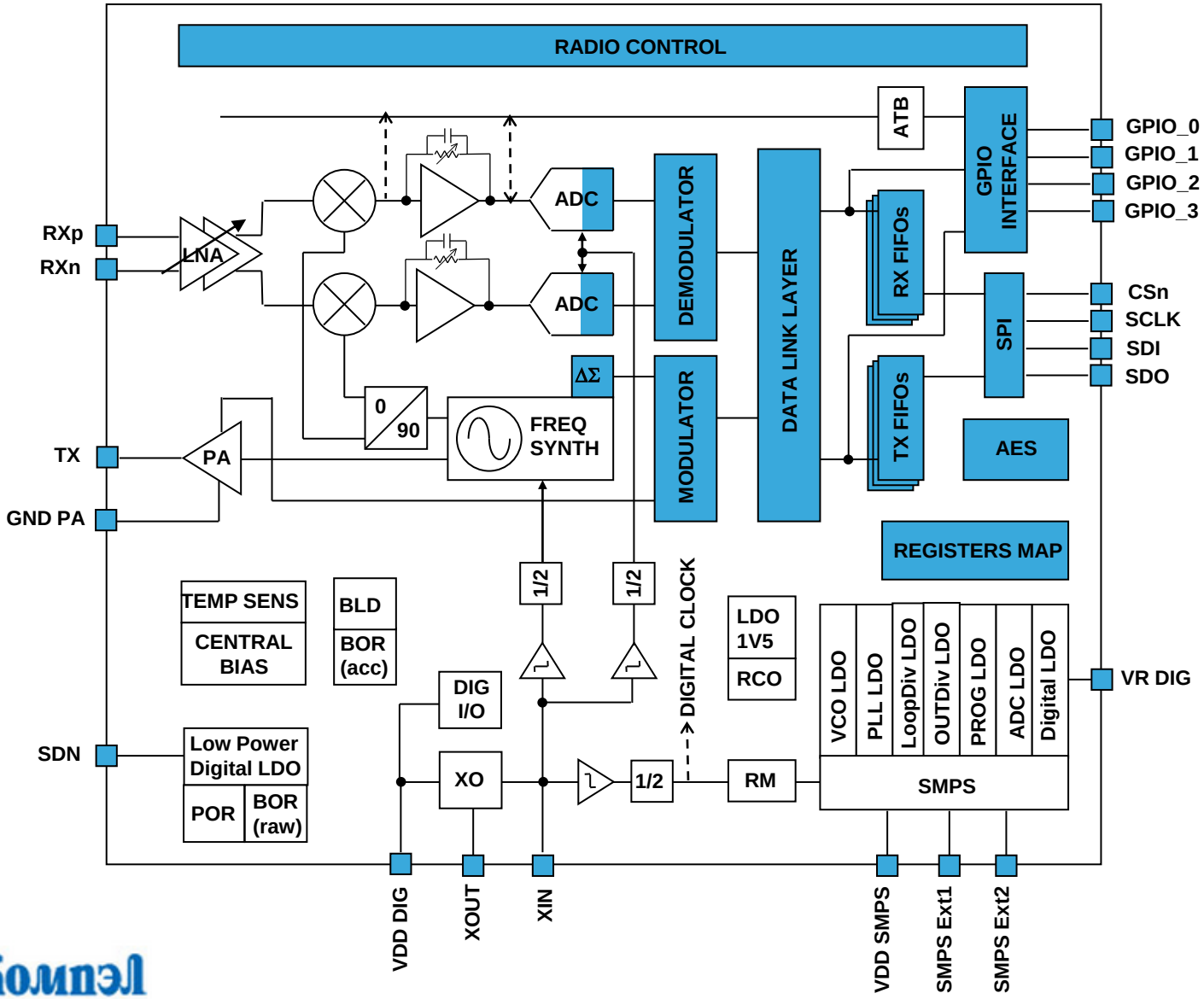
SPIRIT1: Key Features

- **Integrated packet handler**
  - **Support for automatic acknowledgment, retransmission, low duty cycle protocol and timeout protocol**
- **Automatic clear channel assessment (CCA) engine**
  - **Channel access mechanism, based on the rule ‘’Listen-before-talk’’ systems. Embedded CSMA/CA protocol**
- **Fully integrated ultra low power RC oscillator**
- **AES 128-bit encryption co-processor for secure data transfer**

SPIRIT1: Key Features

- **Frequency Hopping under MCU control**
  - **Calibration can be made each time the MCU decide to change frequency or MCU can save and restore calibration data to make the frequency hopping faster**
- **Separate 96-byte RX/TX FIFOs**
  - **accessible via the SPI interface for host processing**
- **Supports automatic antenna selection through an integrated antenna diversity switching mechanism**

SPIRIT1 Block Diagram



Main Block Description

- **Receiver**
  - Architecture based on LOW IF conversion
  - The received RF signal is amplified by a two-stage low noise amplifier (LNA) and down-converted in quadrature (I and Q) to the intermediate frequency (IF). At IF, the I/Q signals are digitized by high dynamic range ADCs.
  - The Demodulator data is then provided to an external MCU either through the 96-byte RX FIFO, readable via SPI, or via a GPIO pin
- **Transmitter**
  - Architecture is based on direct synthesis of the RF frequency
  - The data to be transmitted are provided by an external MCU either through the 96-byte TX FIFO writable via SPI, or directly using a programmable GPIO pin
- **Power Management**
  - Integrates a high efficiency step-down converter (SMPS) cascaded with LDOs to supply both analog and digital parts.
  - Operates from a battery voltage ranging from 1.8 V to 3.6V, with high power efficiency

Main Block Description

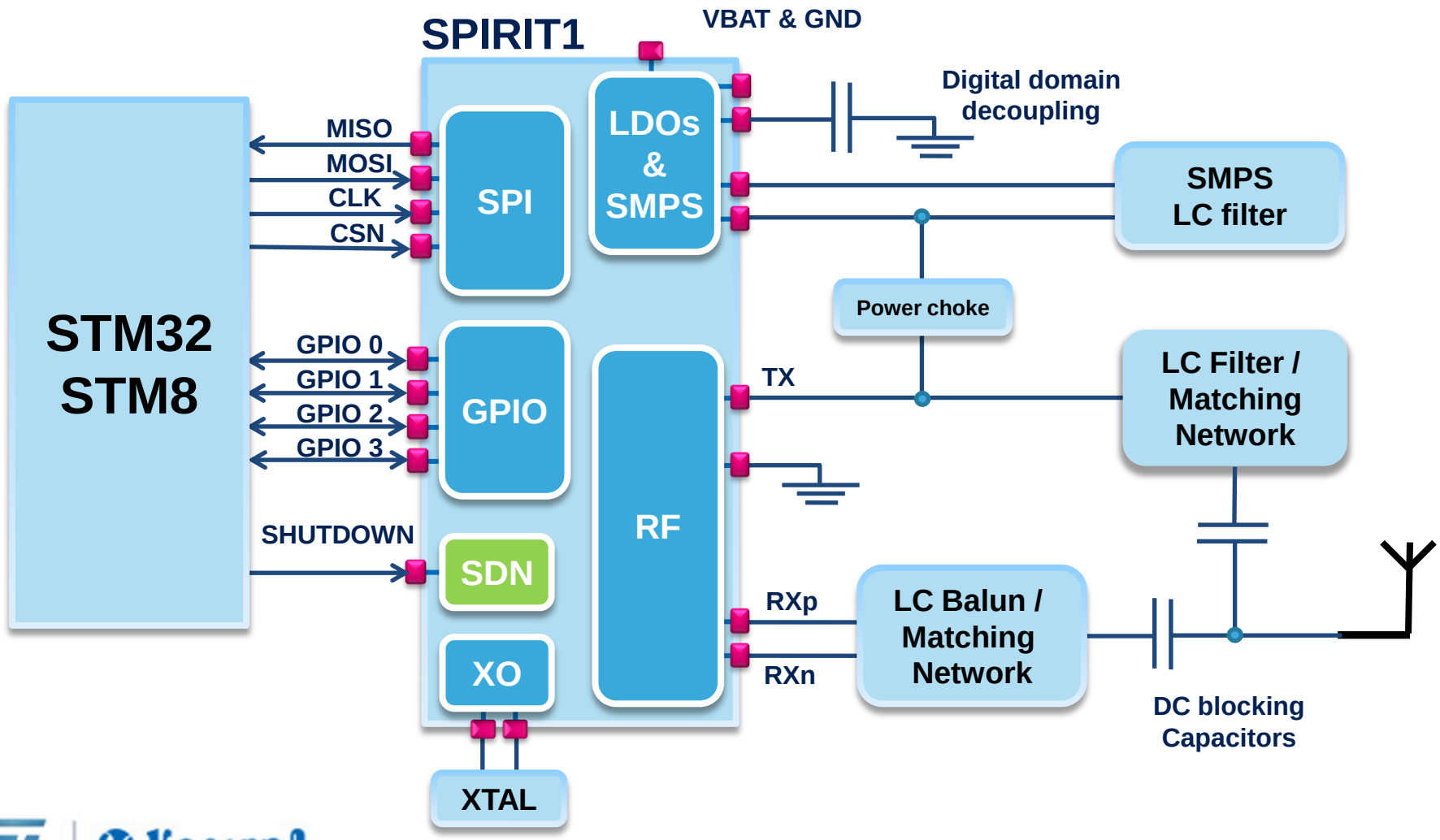
- **Clock Signal : External crystal**
  - **An external 24, 25, 26, 48, 50 or 52 MHz Crystal (between XIN and XOUT) or an external clock signal can be used**
  - **An integrated low-power RC oscillator, generating the 34.7 kHz signal is used as a clock for the slowest timeouts (i.e low duty cycle protocol or CSMA/CA protocol)**

- **Digital Interface**
  - **A 4-wire SPI serial interface is used to communicate with the external MCU.**
  - **4 GPIOs that can be registered through the SPI registers to perform various functions, including**
    - MCU clock output
    - FIFO status flags
    - Wake-up input
    - Battery level detector
    - TX-RX external switch control
    - Antenna diversity control
    - Temperature sensor output
    - Interrupts

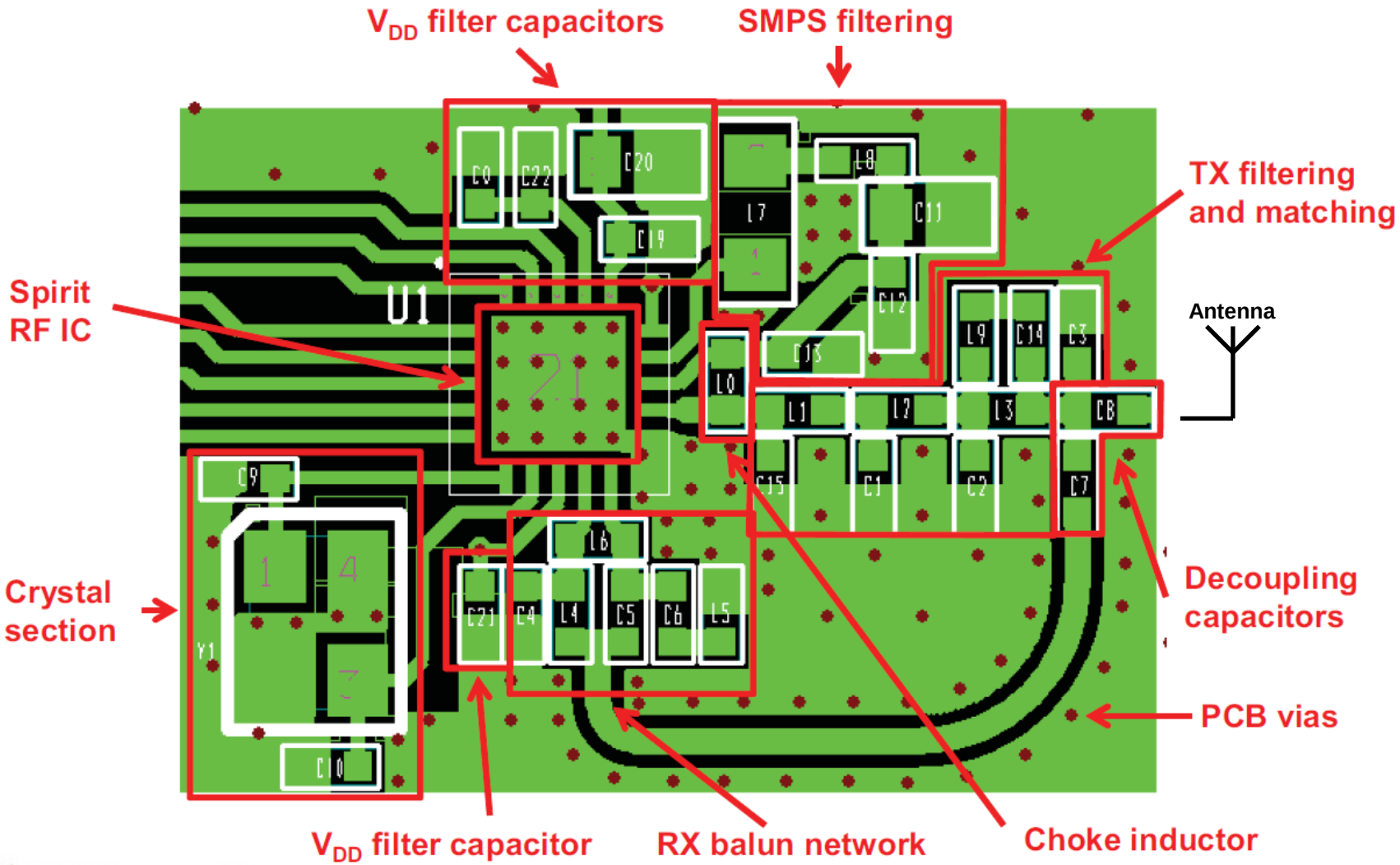
Main Block Description

- **Data link layer**
  - Support for channel configuration, packet handling and data buffering
  - Support Packet Formats (Basic, STack and Wireless M-BUS)
  - The Host MCU can stay in power down until a valid RF packet has been received, and then burst read the data, greatly reducing the power consumption and computing power required from the host MCU
- **AES encryption co-processor**
  - Provides data security support as it embeds an advanced encryption standard (AES128) core which implements a cryptographic algorithm
- **Analog temperature sensor**
  - The Host MCU can be used to read the chip temperature (e.g. it can be used to force radio recalibration)
- **Battery indicator and low battery detector**

SPIRIT1 Application Diagram



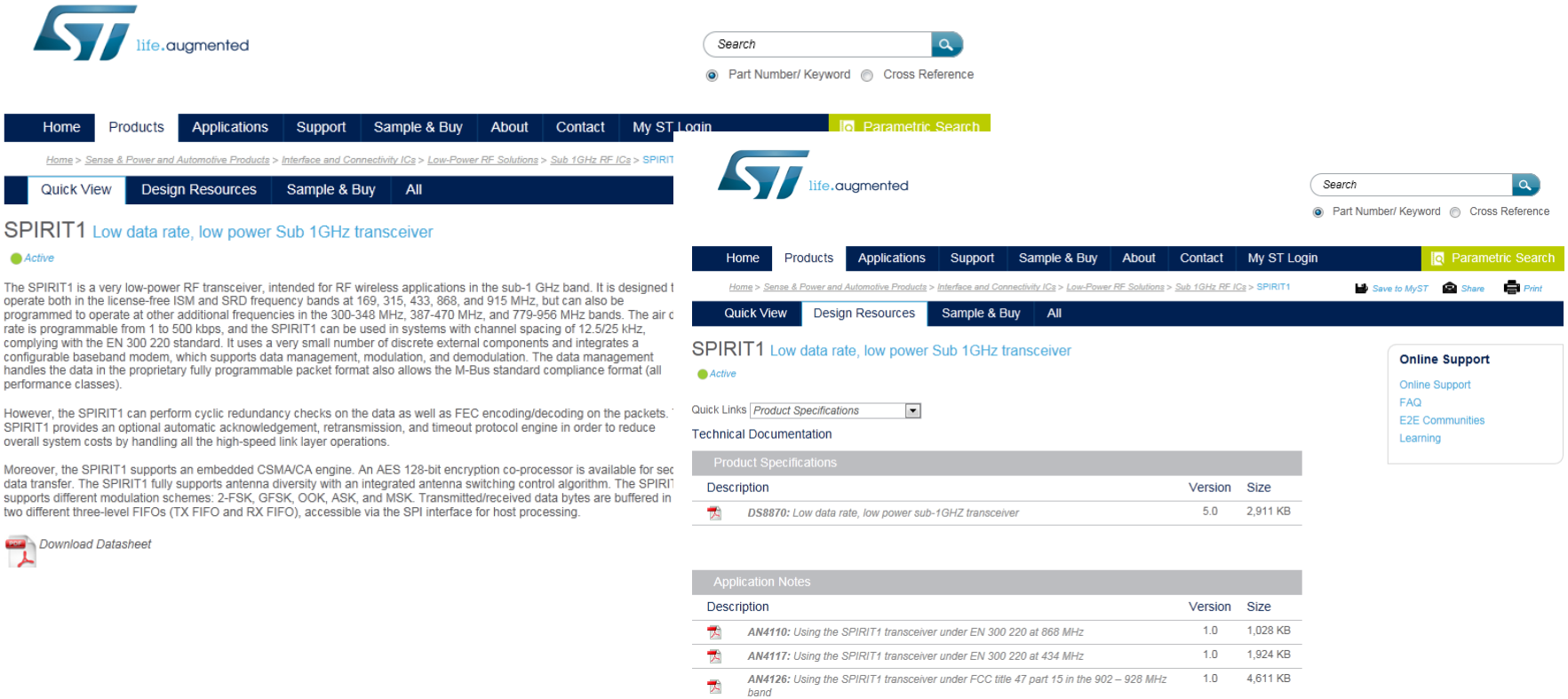
SPIRIT1 PCB layout



SPIRIT1 on Internet

- **Product RTM with All Documentation available at**

http://www.st.com/web/catalog/sense_power/FM1968/CL1976/SC1845/PF253167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SPIRIT1 Low data rate, low power Sub 1GHz transceiver
Active
The SPIRIT1 is a very low-power RF transceiver, intended for RF wireless applications in the sub-1 GHz band. It is designed t
operate both in the license-free ISM and SRD frequency bands at 169, 315, 433, 868, and 915 MHz, but can also be
programmed to operate at other additional frequencies in the 300-348 MHz, 387-470 MHz, and 779-956 MHz bands. The air d
rate is programmable from 1 to 500 kbps, and the SPIRIT1 can be used in systems with channel spacing of 12.5/25 kHz,
complying with the EN 300 220 standard. It uses a very small number of discrete external components and integrates a
configurable baseband modem, which supports data management, modulation, and demodulation. The data management
handles the data in the proprietary fully programmable packet format also allows the M-Bus standard compliance format (all
performance classes).
However, the SPIRIT1 can perform cyclic redundancy checks on the data as well as FEC encoding/decoding on the packets.
SPIRIT1 provides an optional automatic acknowledgement, retransmission, and timeout protocol engine in order to reduce
overall system costs by handling all the high-speed link layer operations.
Moreover, the SPIRIT1 supports an embedded CSMA/CA engine. An AES 128-bit encryption co-processor is available for sec
data transfer. The SPIRIT1 fully supports antenna diversity with an integrated antenna switching control algorithm. The SPIRIT
supports different modulation schemes: 2-FSK, GFSK, OOK, ASK, and MSK. Transmitted/received data bytes are buffered in
two different three-level FIFOs (TX FIFO and RX FIFO), accessible via the SPI interface for host processing.
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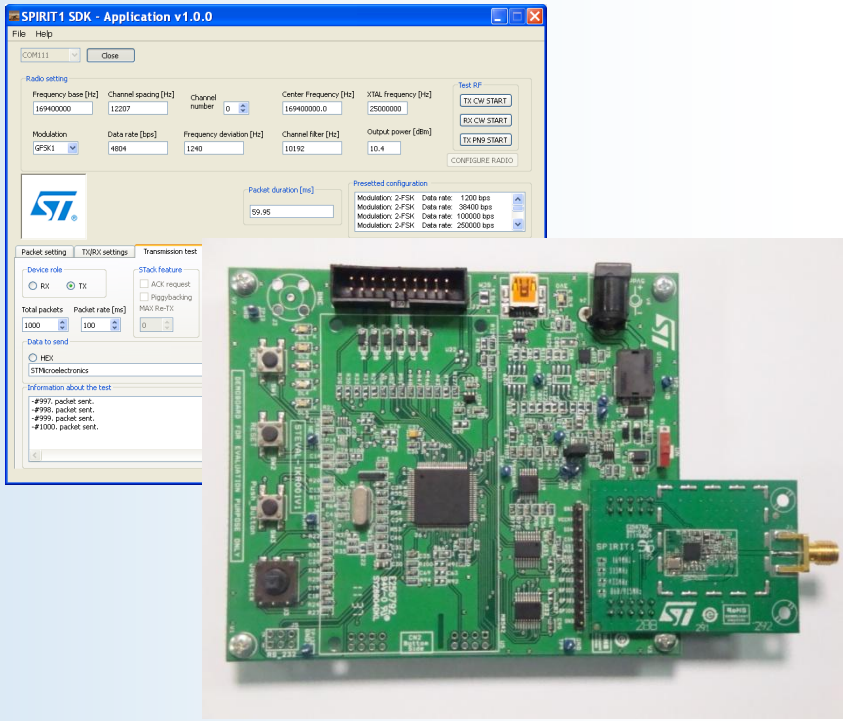
Quick Links
Product Specifications
Technical Documentation
Product Specifications
Description
Version
Size
DS8870: Low data rate, low power sub-1GHZ transceiver
5.0
2,911 KB
Application Notes
Description
Version
Size
AN4110: Using the SPIRIT1 transceiver under EN 300 220 at 868 MHz
1.0
1,028 KB
AN4117: Using the SPIRIT1 transceiver under EN 300 220 at 434 MHz
1.0
1,924 KB
AN4126: Using the SPIRIT1 transceiver under FCC title 47 part 15 in the 902 – 928 MHz band
1.0
4,611 KB

- **Application Notes, Schematics, BOM, Gerber Files, …**
- **opment Kit (SDK) for STM32L, includes WM-Bus library, Set of Thingsquare MIST (6lowPAN, MESH)**

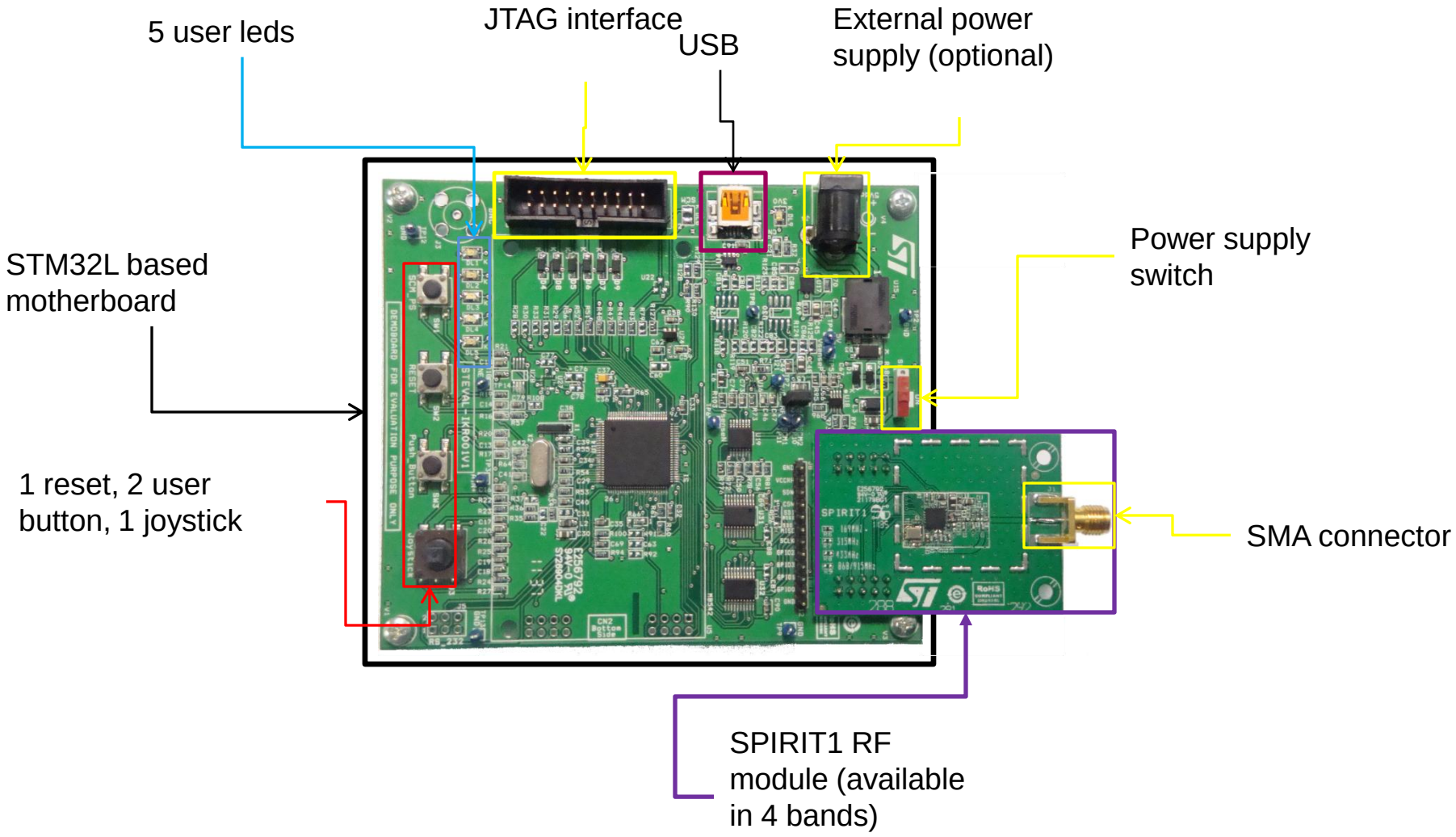
Development Kits

- **SPIRIT1 Development Kits**
  - **STEVAL-IKR001V1 – 169 MHz**
  - **STEVAL-IKR001V2 – 315 MHz**
  - **STEVAL-IKR001V3 – 433 MHz**
  - **STEVAL-IKR001V4 – 868MHz**
  - **STEVAL-IKR001V5 – 915 MHz**
  - **STEVAL-IKR001V6 – 920 MHz**

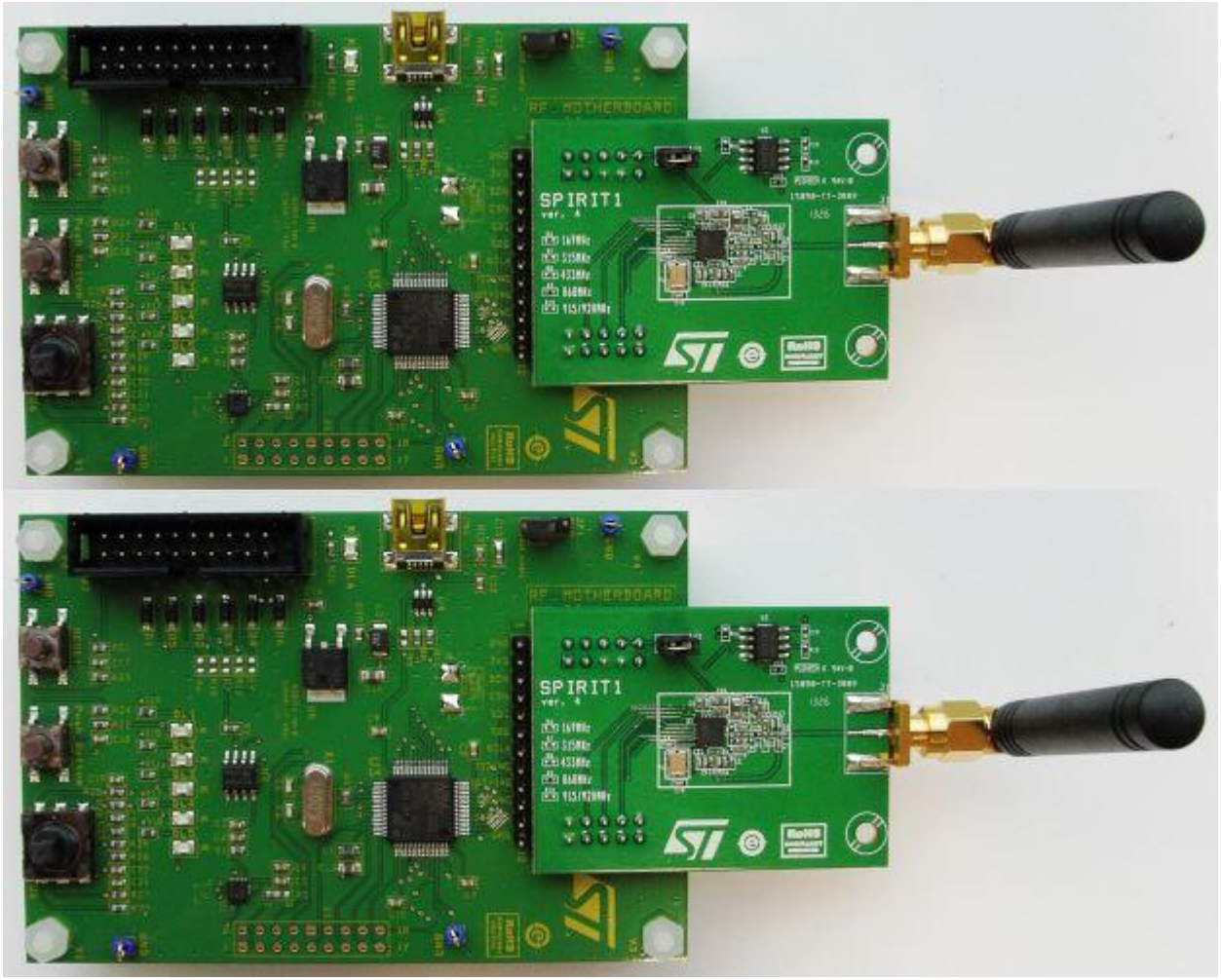


- **Development kit content**
  - **2 x STM32L based motherboard**
  - **2 x SPIRIT1 RF modules**
  - **2 x Antennas**
  - **2 x USB cables**
  - **Software development kit (SDK) has to be downloaded from http://www.st.com**
    - **Includes ST Wireless MBUS stack, Examples, Documentation**
  - **Kit boards are preprogrammed with a firmware for GUI evaluation (DFU for firmware upgrade over USB)**

SPIRIT1 Development kit description

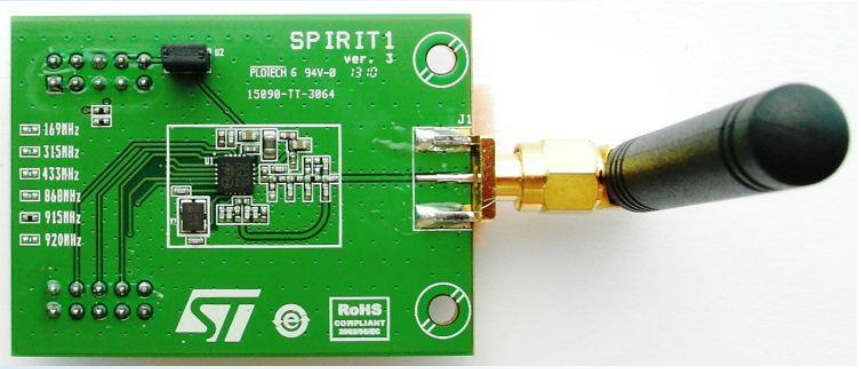


SPIRIT1 – NEW Development kit STEVAL-IKR002Vx



RF module boards

- **SPIRIT1 RF module boards**
  - **STEVAL-IKR001V1D – 169 MHz**
  - **STEVAL-IKR001V2D – 315 MHz**
  - **STEVAL-IKR001V3D – 433 MHz**
  - **STEVAL-IKR001V4D – 868MHz**
  - **STEVAL-IKR001V5D – 915 MHz**



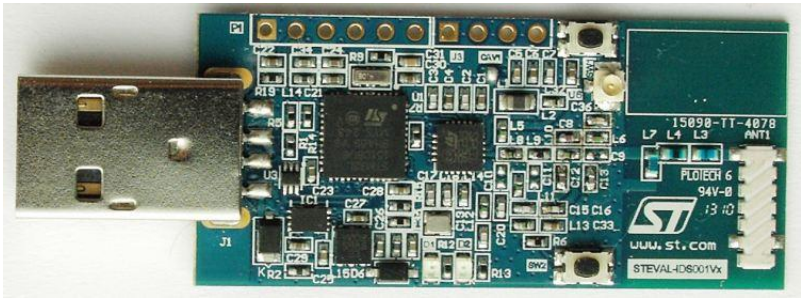
- **Package content**
  - **1 x SPIRIT1 RF module**
  - **The RF module is compatible with STM32L mother board from the development kit**

Coming soon!

STEVAL-IDS001Vx

- **STEVAL-IDS001Vx demo kit RF Dongle**
  - SPIRIT1 RF transceiver
  - STM32L151CBU6 MCU
  - Ceramic antenna + U.FL connector
  - LDS3985PU33R, LDO
  - USBLC6-2P6, protection
  - M95256-RMC6TG - EEPROM
  - SWD connector for debugging

STEVAL-IDS001V2 – 315 MHz
STEVAL-IDS001V3 – 433 MHz
STEVAL-IDS001V4 – 868 MHz
STEVAL-IDS001V5 – 915 MHz



Why SPIRIT1 is better?

- **SPIRIT1 does not need an external PLL loop filter**
- **SPIRIT1 does not need an external tank for the VCO**
- **SPIRIT1 does not need an external TX SAW filter to reduce spurious emissions**
- **SPIRIT1 does not need any external SAW filter in RX to obtain good image rejection**
- **SPIRIT1 has single ended TX - lower current consumption than the differential TX output**
  - **Single ended TX is more practical** for attachment to external PAs available in the market
- **SPIRIT1 differential RX input is less sensitive to noise**
  - Configuration with TX and RX connected together does not allow to use an external range extender and/or an antenna switch, with SPIRIT1 it is possible
- **SPIRIT1 has an excellent RX time-out management**
  - Any AND/OR combination of CS, SQI and PQI valid signals can be used to guarantee that the receiving of a valid packet will be not interrupted by time-out

Sub 1GHz RF Transceiver: STS2001

QFN32 5*5

- **Frequency bands**: 150-174MHz, 300-348 MHz, **400-512 MHz,** 779-956 MHz
- **Modulation schemes**: 2-FSK, 2-GFSK, **4-FSK, 4-GFSK**, MSK, OOK and ASK
- **Air data rate** from **0.1** to **500** kbps (2 levels modulation). From **0.2** to **1000** kbps (4 levels modulation)
- **Programmable output power**: from -30dBm to +**20** dBm
- **Receiver Sensitivity: -122dBm** @ 1.2kbps
- **Low current consumption**
  - **Shutdown: 2.5nA**
  - **Stand-by: 600nA**
  - **Sleep: 900nA**
  - **RX: 10mA**
  - **TX: 24 mA @+11dBm**
- Frequency Hopping, Antenna diversity algorithm
- Automatic acknowledgement, retransmission, and timeout protocol engine
- Embedded packet handler
- Wireless M-BUS including the **N2g sub mode**, 6LoWPAN
- EN 300 220, FCC CFR47 15 (15.205, 15.209, 15.231, 15.247, 15.249), and ARIB STD T-67, T-108 compliant.

Evaluation board availability: June 2013

Production ramp up: June 2013

Mass production: October 2013

STS1TX Sub 1GHz RF Transmitter

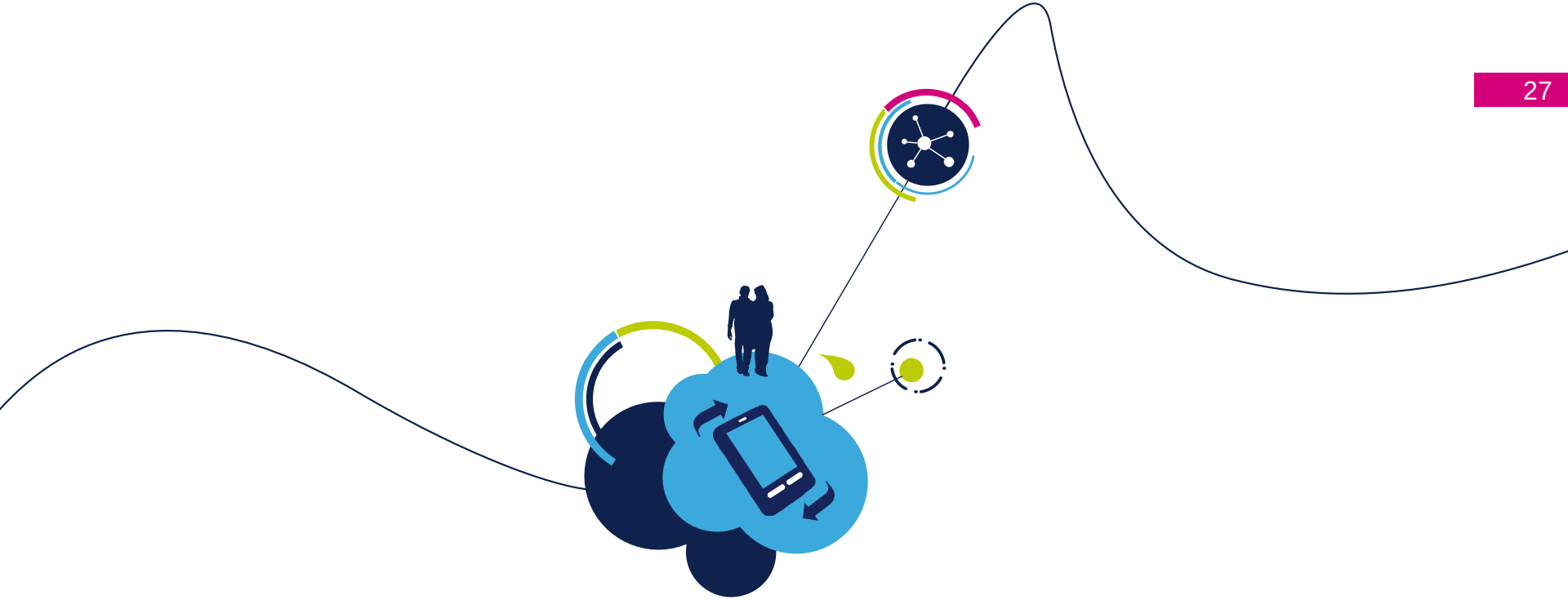
- **Sub 1GHz Transmitter**
- **Pin to pin and footprint compatible** with the SPIRIT1
- RF/ANALOG performance = SPIRIT1
- **Link Layer** and **Packet handler** support = SPIRIT1
- Main Characteristics:
  - **Frequency bands**: 150-174MHz, 300-348 MHz, 387-470 MHz, 779-956 MHz
  - **Modulation schemes**: FSK, GFSK, MSK, OOK and ASK
  - **Air data rate** from 1 to **500 kbps**
  - **Programmable output power**: from -30dBm to +16dBm (boost mode)
  - **Low current consumption**
  - **Programmable channel spacing** (12.5 kHz min).
  - **Frequency Hopping**
  - **AES 128-bit encryption co-processor**
  - **Embedded packet handler**
  - **Wireless M-BUS**, **6LoWPAN**
  - **EN 300 220, FCC CFR47 15** (15.205, 15.209, 15.231, 15.247, 15.249), and **ARIB STD T-67, T-108** compliant

QFN20 4*4

Samples and mass production: June 2013

SPIRIT1: Summary

- **Multi Band Transceiver, Targeting the Following Applications :**
  - Wireless Metering and Wireless Smart Grid
  - Home & Building Automation
  - Industrial Monitoring and Control
  - Wireless Fire and Security Alarms
- **Best in Class Solution in Power Saving : Cuts power budget by 30% over competing devices**
- **Excellent RF performances : High Sensitivity, High Selectivity, Antenna Diversity ensuring reliability & robustness performances**
- **Compliant Wireless MBus standard**
- **Demo Kit @ All frequency Band available NOW**
- **Product in Mass Production**



RF Basics

Basic Terminology 1/2

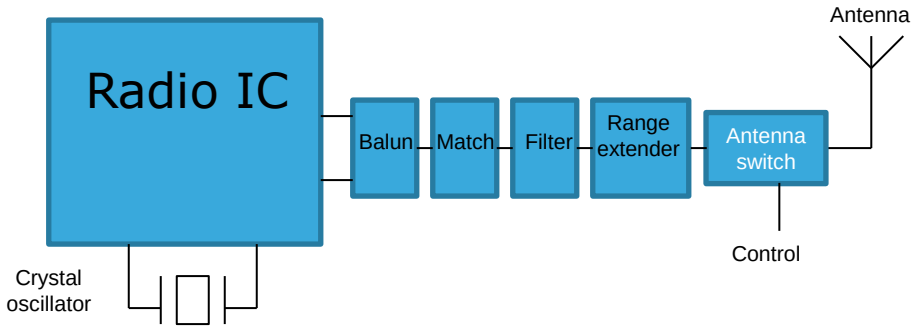
- dBm – is a measure of RF Power referred to 1 mW (0 dBm)
  - 10mW(10dBm), 500 mW (27dBm)
- PER – Packet Error Rate [%] – percentage of the packets not successfully received over a period of time
  - Used to measure the RF transceiver performance
- BER – Bit Error Rate [%] - percentage of the Bits not successfully received over a period of time
  - Used to measure the RF transceiver performance
- Sensitivity (RX) – it is the lowest input power of the receiver acceptable to receive packets with 1% PER
- Blocking (RX) – The receiver ability to work in the presence of a interfering RF signal in a frequency band relatively close to the signal of interest

Basic Terminology 2/2

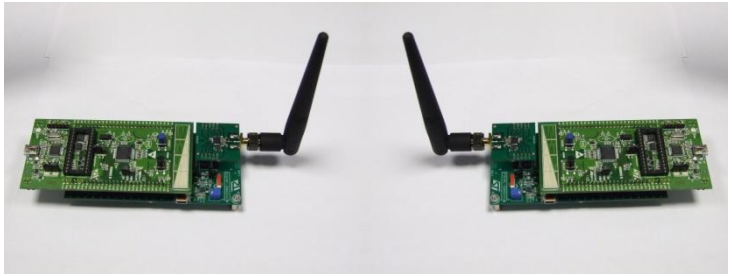
- Dynamic range - the maximum received power variation at the receiver input pins which result in a correct demodulated signal
- Adjacent Channels – channel(s) closest to the active signal channel
- Alternate Channel – second next channel(s) to the active signal channel
- Payload – application data
- Modulation – superimposing algorithm of a low frequency signal (payload) onto a high frequency signal (Carrier)
  - ASK, OOK, FSK, GFSK, GMSK

RF system

- Radio IC
  - Transmitter (only TX)
  - Receiver (only RX)
  - Transceiver (both TX & RX)
  - SoC (Transceiver + MCU)

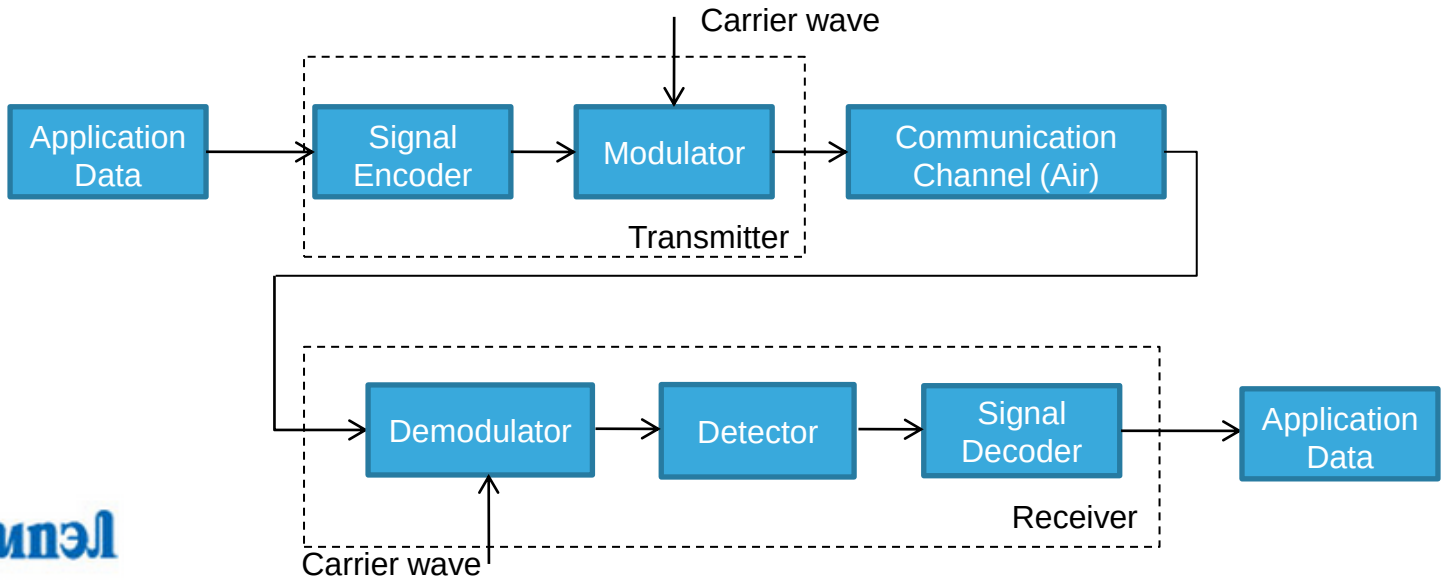


- Crystal
  - Clocks the Radio IC crystal oscillator which generates the reference frequency for the RF synthesizer
- Balun
  - converts balanced (differential) signal to unbalanced (single-ended) signal and the vice versa.
- Matching network
  - whenever a source of power with a fixed output impedance such as a radio transmitter operates into a load, the maximum possible power is delivered to the load when the impedance of the load is equal to the complex conjugate of the impedance of the source
- Filter
  - attenuates out of band signals
- Antenna switching
  - Either can be used to switch from antenna to antenna with a better RSSI value, or is switching the antenna either to the RX to TX chain between the antenna and the radio IC
- Range Extender
  - can be used to increase the radiated output power
- Antenna
  - converts electric power into radio waves



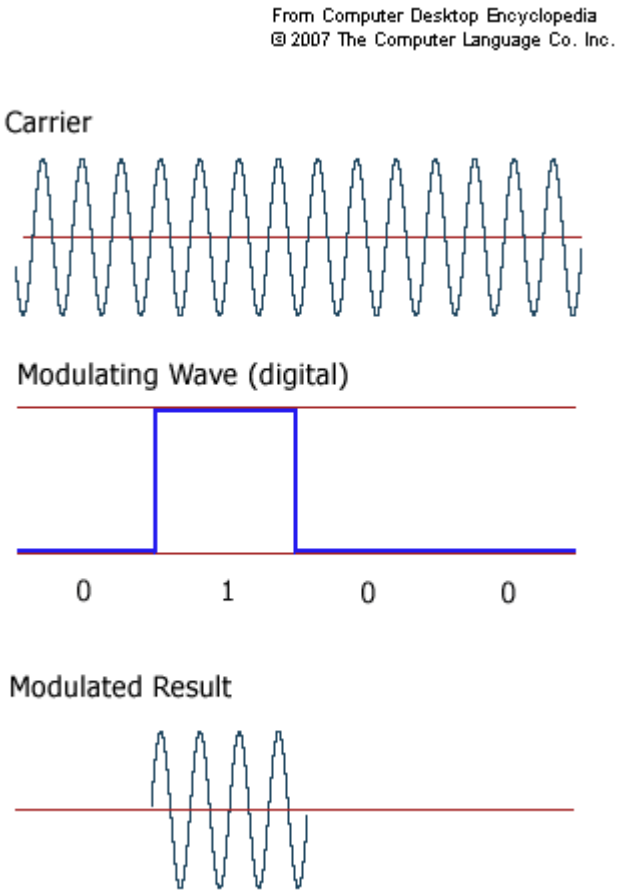
Complete RF communication environment

- Signal encoder / decoder
  - converts information from one format or code to another, for the purposes of standardization, speed, security or saving space by shrinking size (e.g. Manchester), decoder does the opposite
- Modulator
  - process of varying one or more properties (amplitude, frequency, ..) of a high-frequency periodic waveform, called the carrier wave, with a modulating signal which typically contains information to be transmitted (Application Data)
- Communication channel
  - is the physical transmission medium as a wire or, as in our case, a radio channel
- Demodulator / Detector
  - Recovers the information content from the modulated carrier wave



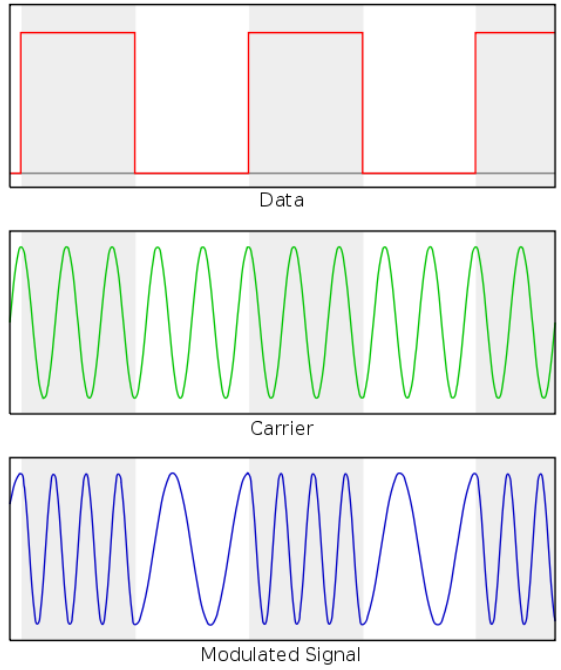
Digital Amplitude modulation methods

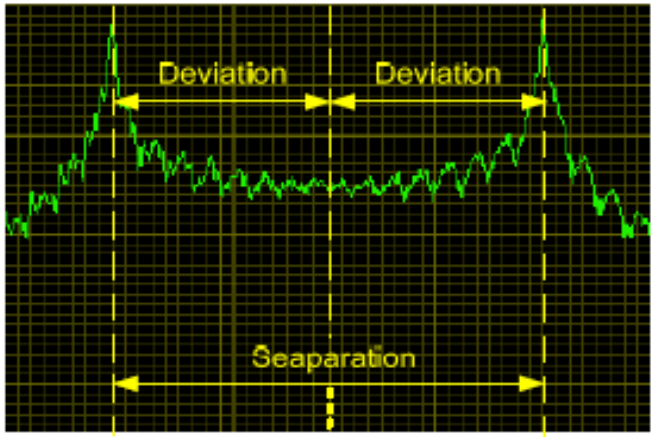
- ASK (Amplitude Shift Keying)
  - The amplitude of an analog carrier signal varies in accordance with the digital bit stream
  - The amplitude of the carrier is set to a max level when a 1 is sent and a min level when a 0 is sent
  - Simple, duty cycling, lower transmit current
  - Susceptible to noise, wide spectrum
- OOK (ON OFF Keying)
  - It is the simplest form of ASK
  - It represents digital data as the presence or absence of a carrier



Digital frequency modulation method (1/2)

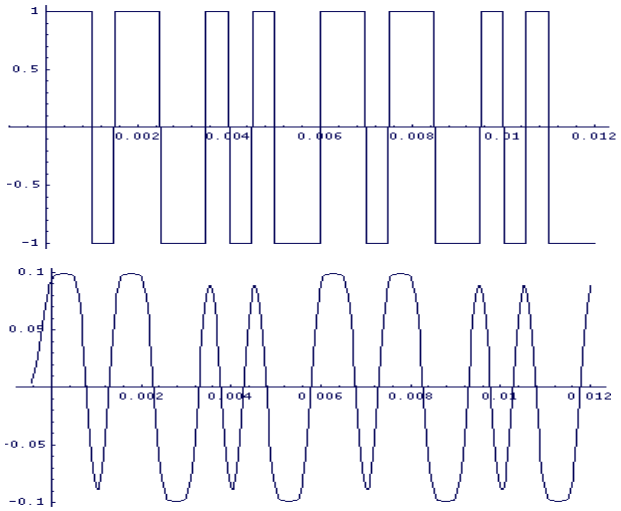
- FSK
  - The digital information is transmitted through discrete frequency changes of a carrier
  - Less susceptible to noise
  - Theoretically it requires larger bandwidth than ASK
- 2-FSK (Two level or binary FSK)
  - A pair of discrete frequencies is used to transmit 1/0

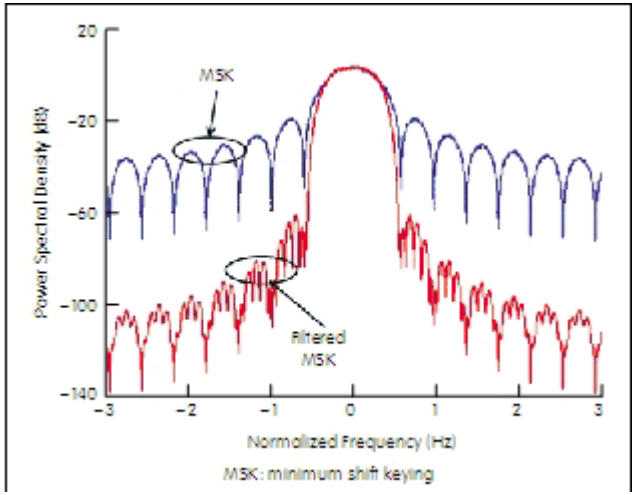




Digital frequency modulation method (2/2)

- GFSK (Gaussian FSK)
  - A Gaussian filter smoothes baseband data (1/0) to make the pulse smoother
  - It has better spectral width than 2-FSK
- MSK and GMSK
  - MSK (Minimum Shift Keying)
    - Is a type of continuous-phase frequency-shift keying (CP-FSK)
    - Is implemented as a fast frequency-shift keying (FFSK)
    - The results is a constant-modulus signal => reduces problems caused by distortion
  - GMSK (Gaussian Minimum Shift Keying)
    - A Gaussian filter is applied to smooth the incoming digital data





SPIRIT1
Technical Details

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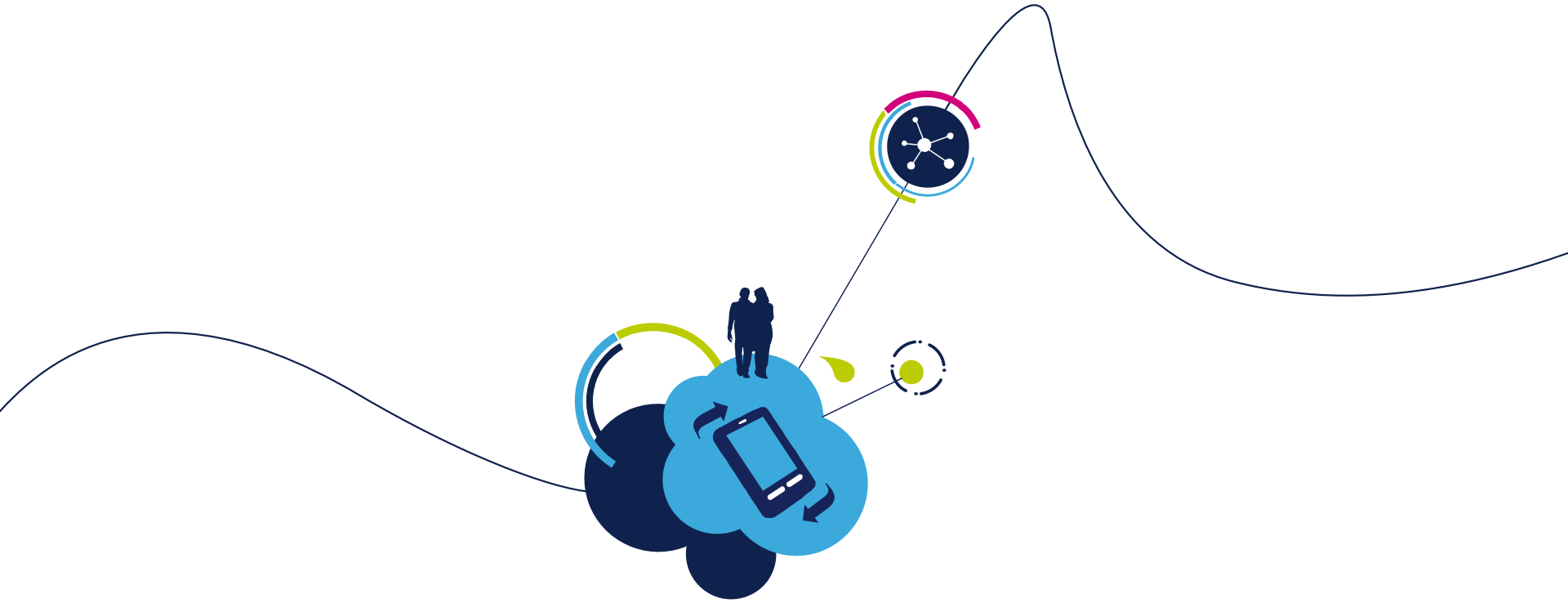

State Machine, MCU Control Interface & AES128

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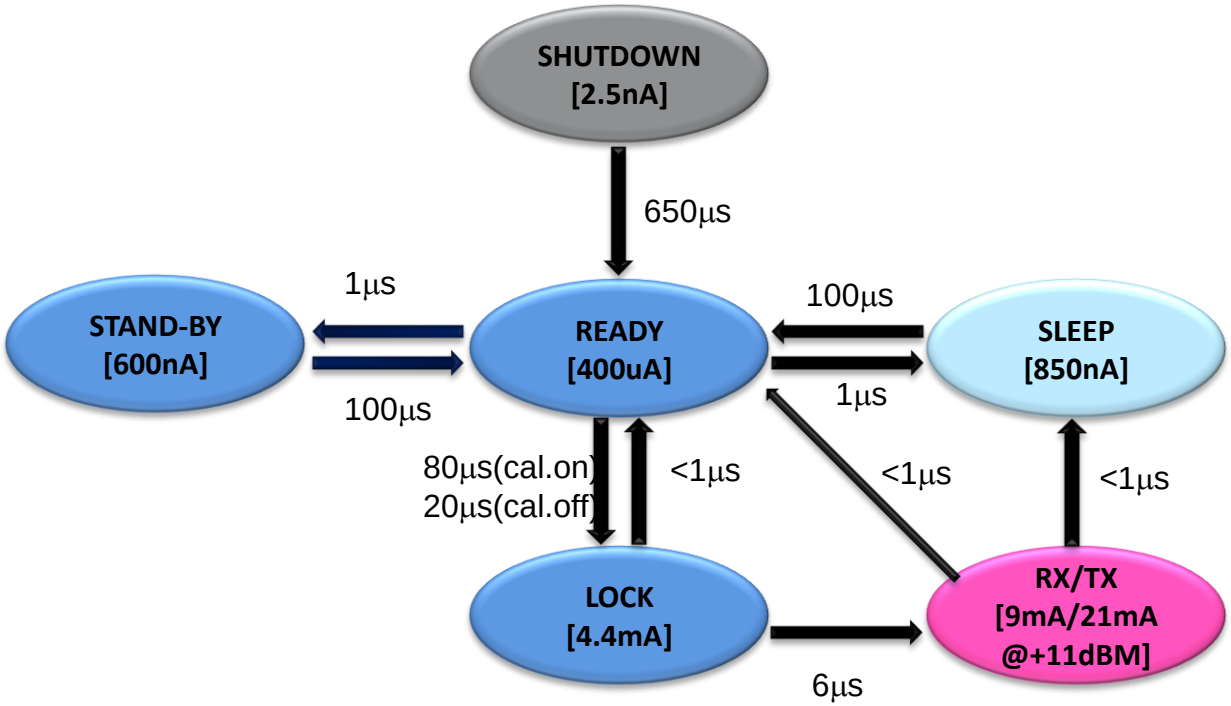
Operating Modes/Consumption



Mode	Description
Shutdown	Off, no register retention
Standby	SPI On, register retention
Sleep	SPI on, register retention, Wakeup timer on
Ready	SPI on, XTAL on
RX	SPI on, XTAL on, RF Synth on
TX	SPI on, XTAL on, RF Synth on

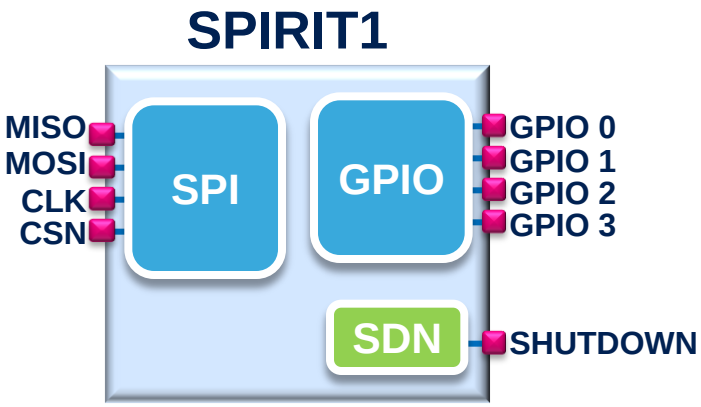
Built-in main controller handles operating mode transitions

Transition times using 26MHz Xtal

MCU interface

SPI communication

- Write registers or FIFOs
- Read registers or FIFOs
- 17 Commands (State diagram, AES, FIFO flush)



GPIO communication

- Interrupt signals
- Monitoring signals (Valid preamble detected, valid sync word detected, …)
- Commands (TX/RX mode, Wake-up from external input, …)
- Input/output data (direct mode)
- Input/output reference clock (MCU clock out, 34.7 kHz for LDC mode input)
- Analog output: temperature sensor (GPIO 0)

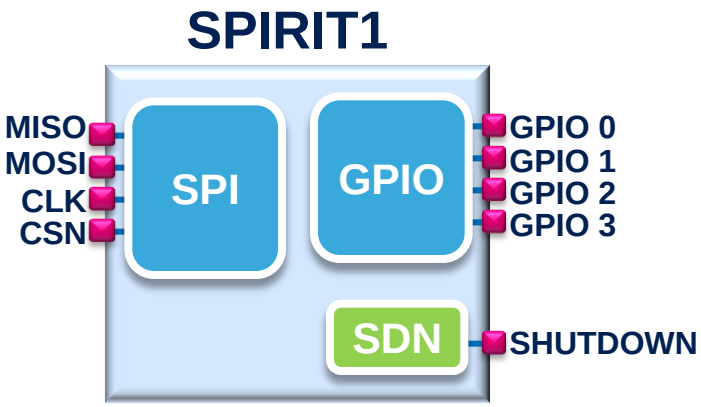
SDN pin

- Shutdown signal

Monitoring signals

GPIO communication

- **Monitoring signals**



Packet oriented
Valid preamble detected
Sync word detected
RSSI above threshold

FIFOs oriented
TX FIFO almost full
TX FIFO almost empty
RX FIFO almost full
RX FIFO almost empty

Status oriented
Device in READY state
Device in SLEEP or STANDBY states
TX state indication
RX state indication
TX or RX mode indicator
Device in LOCK state

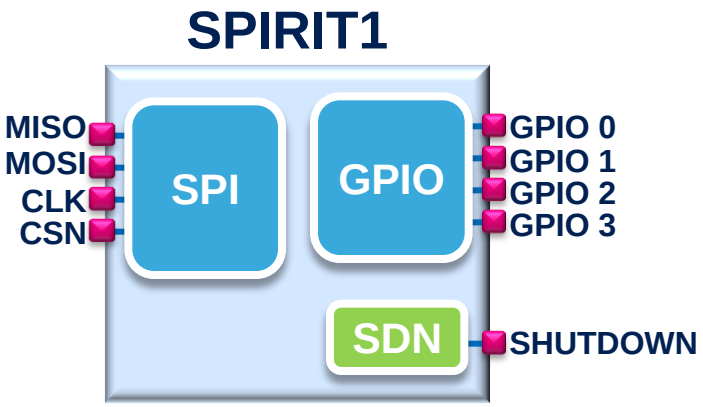
Status oriented
Low battery level
Power-On Reset
Antenna switch used for antenna diversity

Other
VDD/GND (to emulate an additional GPIO of the MCU)
Wake-Up timeout in LDC mode

Interrupts

GPIO communication

- **Interrupt signals**



Packet oriented
RX data ready
RX data discarded
TX data sent
CRC error
Valid preamble detected
Sync word detected
RSSI above threshold

FIFOs oriented
TX FIFO underflow/overflow error
RX FIFO underflow/overflow error
TX FIFO almost full
TX FIFO almost empty
RX FIFO almost full
RX FIFO almost empty

Protocol oriented
Max re-TX reached
Max number of back-off during CCA
Wake-up timeout in LDC mode
AES End–Of – Operation

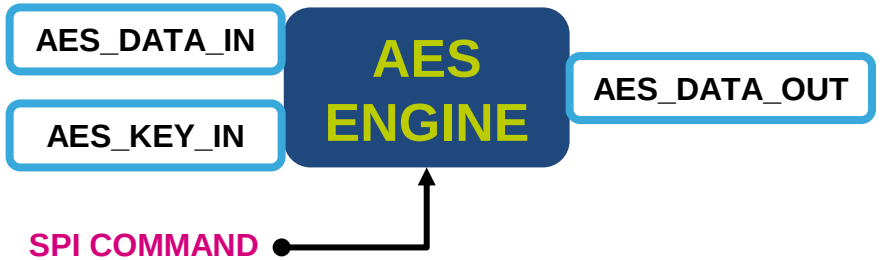
Status oriented
READY state in steady condition
STANDBY state switching in progress
Low battery level
Power-On Reset
RX operation timeout

SPIRIT1 AES-128 Engine

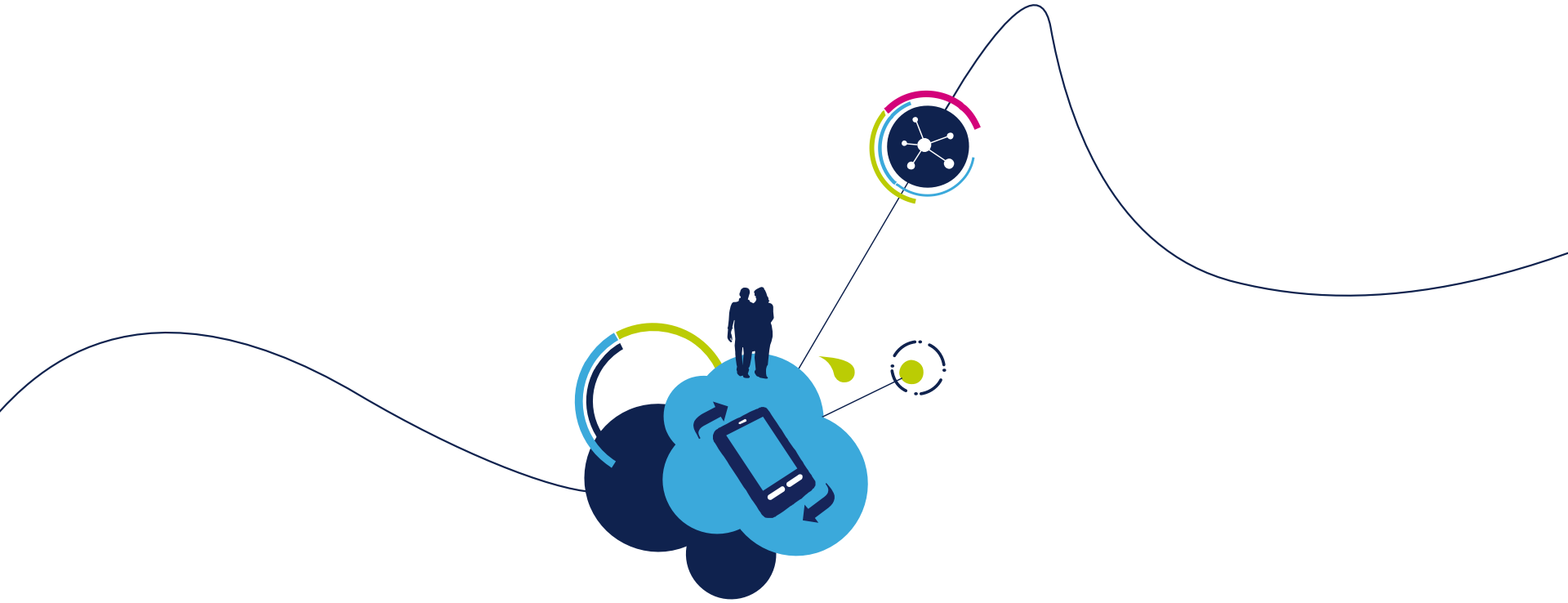
The SPIRIT1 provides data security support as it embeds the Advanced Encryption Standard (AES) 128-bit core.

The AES-128 engine can be used at anytime.

- The SPIRIT1 provides 3 banks of 128 bits registers:
  - Input register (*AES_DATA_IN*)
  - Output register (*AES_DATA_OUT*)
  - Key register (*AES_KEY_IN*).



- Four operations are available:
  - Encryption using a given encryption key.
  - Decryption key derivation starting from an encryption key.
  - Data decryption using a decryption key.
  - Data decryption using a encryption key.



Transmission & Reception

RF Related Features

SPIRIT1 Oscillator and RF synthesizer

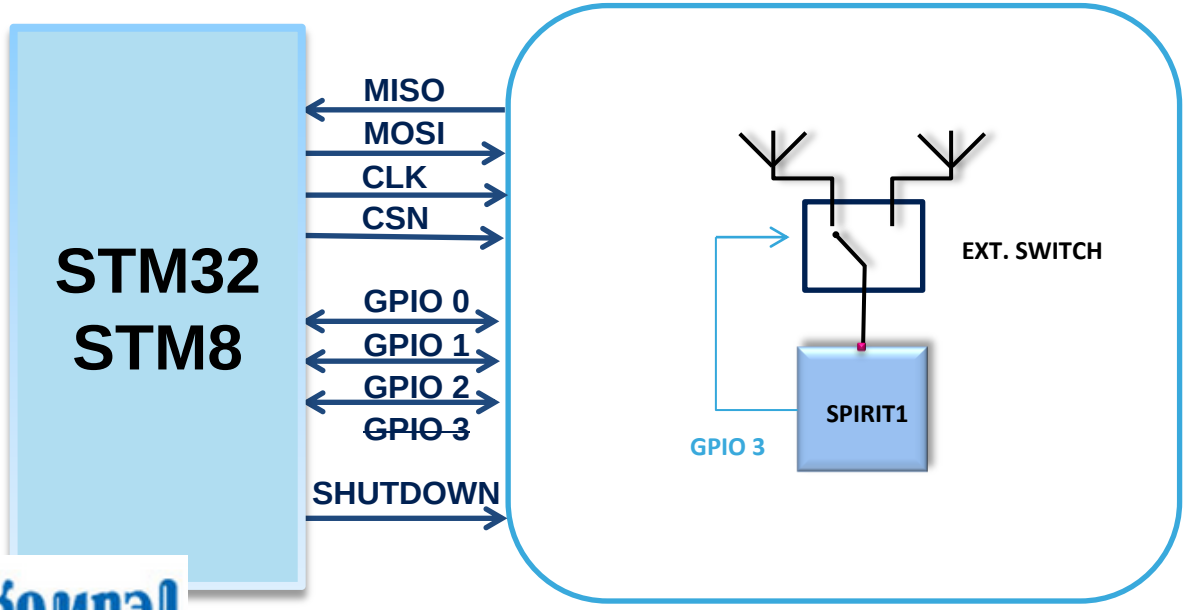
- **An external XTAL (24, 25, 26, 48, 50, 52 MHz), provide a clock signal to the RF frequency synthesizer.**
  - The digital part of the silicon always requires clock in the range (24-26 MHz), so the clock must be divided when using 48-52 MHz XTAL.
- **RF Frequency Synthesizer**
  - has fractional sigma delta architecture for fast settling and narrow channel spacing
  - contains an integrated PLL capable to synthesize frequencies in the bands (150÷174) MHz, (300÷348) MHz, (387÷470) MHz, (779÷956) MHz, providing the LO signal for the RX chain and the input signal for the PA in the TX chain. No external PLL loop filter is needed.
  - uses a multi-band VCO to cover the whole frequency range
- **The base Carrier frequency is programmed using SYNT0-SYNT3 registers of SPIRIT1 (easiest way is to use SPIRIT1 SW library)**
- **Calibration can be automatic (80 us) or manual (20 us), in the latter case the micro should save/restore the calibration words and take into account for temperature/VBAT variation which could require recalibration.**

Receiver Quality Indicators

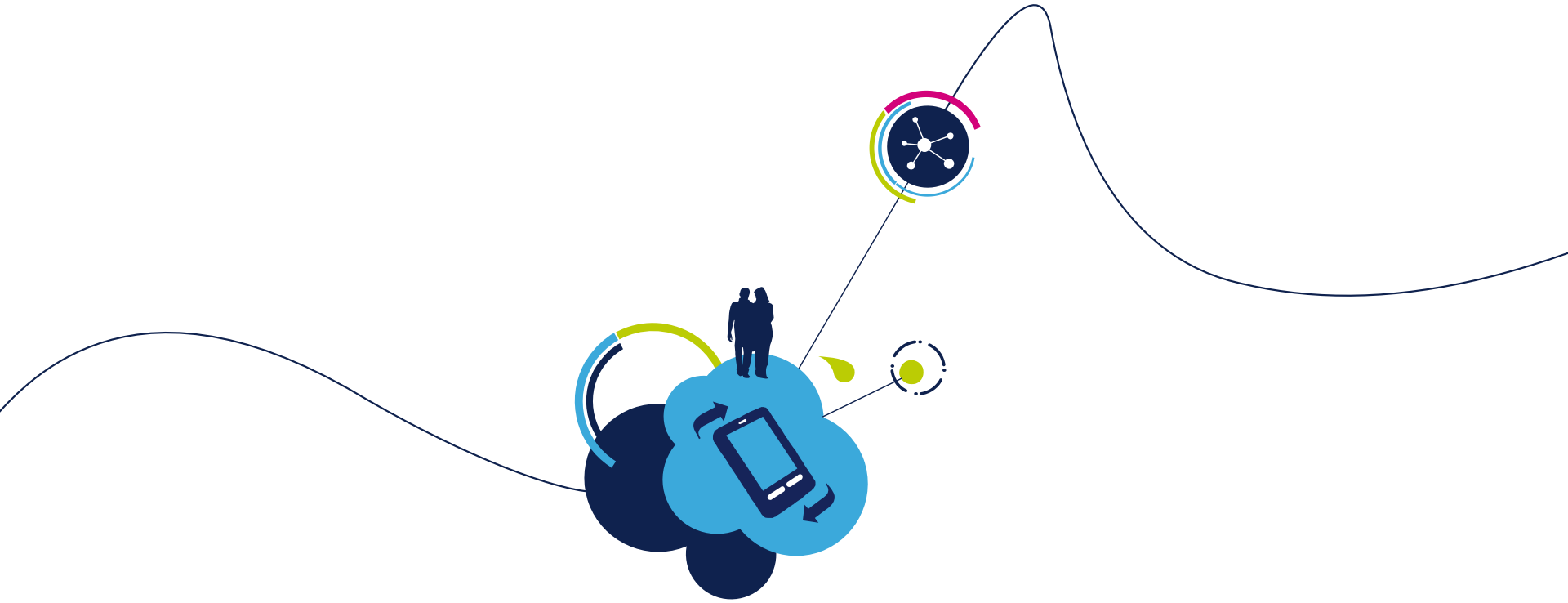
- **Received signal strength indicator (RSSI) – 8 bits**
  - Measured received signal power. RSSI reading is available after the reception of a packet in a register
- **Carrier Sense (CS) – 1 bit**
  - Based on RSSI (threshold, static/dynamic mode)
- **Link quality indicator (LQI) – 4 bits**
  - Level of noise power on the demodulated signal
- **Preamble quality indicator (PQI) – 8 bits**
  - Best correlation between the received preamble and the expected one
  - Preamble valid IRQ can be used
  - Packet demodulation can be stopped when PQI is below threshold
- **Synchronization quality indicator (SQI) – 7 bits**
  - Measurement of the best correlation between the received synchronization word and the expected one
  - Sync word detected IRQ can be used
  - Packet demodulation can be stopped when SQI is below threshold

Automatic Antenna diversity algorithm

- An external switch is controlled to select the antenna with the highest RSSI (through programmable SPIRIT1 GPIO)
- While receiving the packet preamble, the antennas are repeatedly switched until the RSSI > threshold .
- The switch is then disabled and the selected antenna is used.



Any GPIO of SPIRIT1 can be programmed to control the ext. switch



Transmission & Reception

Packet handler Engine

SPIRIT1 Packet Handler Engine

Embedded packet formats

- **STack**

Preamble 1 – 32 Bytes	Sync 1 – 4 Bytes	Length 0 – 16 Bits	Destination Address 1 Byte	Source Address 1 Byte	Control 0 – 4 Bytes	Seq. No. 2 bits	No ACK 1 bit	Payload	CRC 0, 8, 16, 24 bits

- **WM-Bus**

Preamble	Sync	Payload	Postamble

- **BASIC**

Preamble	Sync	Length	Destination Address	Control	Payload	CRC

SPIRIT1 Direct mode

The purpose of the direct modes is to by-pass completely the packet handler engine and to give the user more flexibility. The direct modes are available both for RX and TX

- **Direct mode through FIFO (SPI)**
  - In the direct mode through FIFO the data are continuously read from the TX FIFO and transmitted without any processing of the packet handler for the transmitter and the data are continuously received in the RX FIFO without any processing.
- **Direct mode through GPIO**
  - In the direct mode through GPIO the data are sampled by the device on the rising edge of the clock signal and send on air without any processing of the packet handler for the transmitter and the data are continuously written to one GPIO together with the clock in another GPIO.
- **PN9 mode (for TX)**
  - A pseudo-random binary sequence is generated internally for test purpose only.

SPIRIT1 Automatic Packet Filtering

Embedded automatic packet filtering

- **CRC** (Packet discarded if CRC check do not pass)
- **Destination address** (My own address, Broadcast, Multicast)
- **Source address** (reference address in AND bitwise with the source mask)
- **Control field** (reference address in AND bitwise with the control mask)

The automatic packet filtering engine works in STack and BASIC packet formats

More than one automatic filtering feature can be enabled at the same time

SPIRIT1 Link Layer Protocol

Available through the STack packet format, with following features

- **Automatic acknowledgment**
  - The receiver sends an ACK packet, if a packet is received with success and bit NO_ACK = 0. The transmitter goes in RX state to wait the ACK packet. If the transmitter does not receive any ACK packet when it should, the packet transmitted before is considered lost.
- **Automatic acknowledgment with piggybacking**
  - The receiver can fill the ACK packet with data (as payload field of the packet). The data to send is stored in the TX FIFO (up to 96 bytes without any additional interaction from the MCU !!!)
- **Automatic retransmission**
  - If the transmitter does not receive the ACK packet within the RX timeout programmed, it can be configured to do another transmission. Up to 15 retransmissions.

SPIRIT1 Data coding and integrity check

Error correction and detection methods

- **FEC/Viterbi and interleaving**
  - Convolutional coding in transmitter and on the receiver side - error correction is performed using soft Viterbi decoding
  - Controls errors in data transmission over unreliable/noisy communication channels. The number of transmitted bits is roughly doubled, hence the on-air packet duration in time is roughly doubled as well (~1dB link budget increase)
- **Data whitening/ dewhitening**
  - To prevent short repeating sequences that create spectral lines, which may complicate symbol tracking at the receiver or interferer with other transmissions
- **CRC (Cyclic Redundancy Check)**
  - CRC polynomials can be selected (4 options). Programmable to 8, 16, or 24 bits

CRC and whitening is applied over all fields excl. preamble and synchronization word

Power consumption Efficient use of the **RX timeout mechanism [1/3]**

In order to reduce power consumption, many automatic RX timeout modes are supported

- **Infinite timeout** – RX stops when the packet ends or when the SABORT SPI command comes from the microcontroller
- **Carrier sense (CS) timeout** - RX is aborted if the RSSI never exceeds a programmed threshold within preset timeout (TIMER)
- **SQI timeout** - RX is aborted if the synchronization quality indicator (SQI) does not exceed a programmed threshold within preset timeout
- **PQI timeout** - RX is aborted if the preamble quality indicator (PQI) does not exceed the programmed threshold within preset timeout

The value of the Time out can be programmed up to ~3 seconds

Power consumption Efficient use of the **RX timeout mechanism [2/3]**

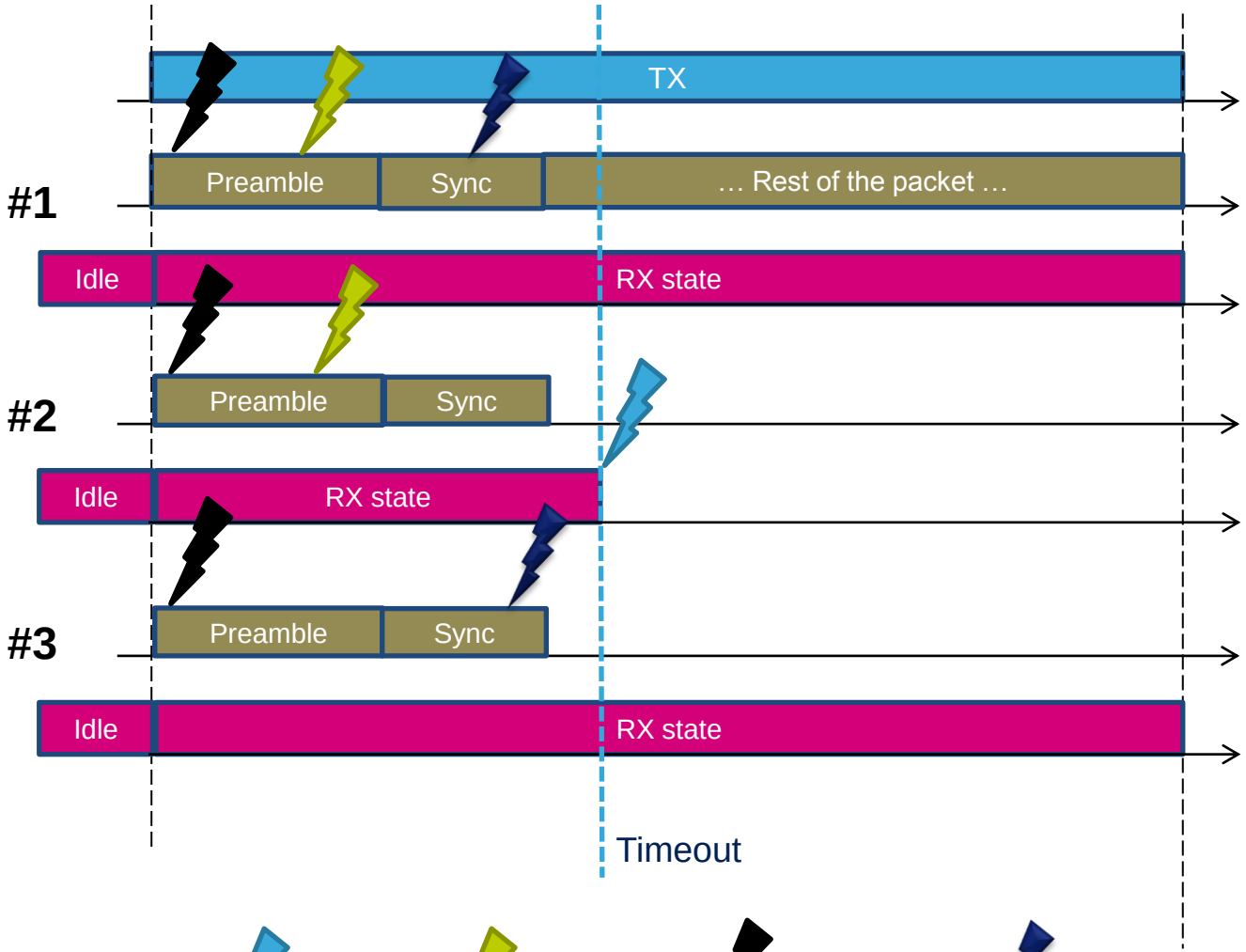
- CS, SQI and PQI can be combined together, both '**AND**' or '**OR**' Boolean relationships among them are allowed to avoid the reception to be interrupted

- It is up to the programmer to effectively set the timeout value (time) according to the application needs (i.e. preamble and sync word length, data rate etc.)

AND / OR SELECT	CS	SQI	PQI	Description
0	0	0	0	Time out not stopped
1	0	0	0	Timeout always stopped (default)
x	1	0	0	CS (RSSI above threshold)
x	0	1	0	SQI above threshold
x	0	0	1	PQI above threshold
0 (AND)	1	1	0	Both RSSI AND SQI above threshold
0 (AND)	1	0	1	Both RSSI AND PQI above threshold
0 (AND)	0	1	1	Both SQI AND PQI above threshold
0 (AND)	1	1	1	ALL above threshold
1 (OR)	1	1	0	RSSI OR SQI above threshold
1(OR)	1	0	1	RSSI OR PQI above threshold
1(OR)	0	1	1	SQI OR PQI above threshold
1(OR)	1	1	1	ANY above threshold

Power consumption Efficient use of the **RX timeout mechanism [3/3]**

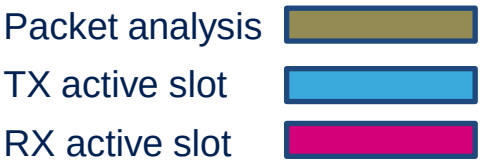
3 examples



1# CS, PQI, SQI being tested in the app. All above threshold, timeout stopped. Packet received.

#2 CS, PQI, SQI being tested in the app. SQI below threshold, timeout was not stopped. Packet not received - demodulation stopped .

#3 CS, SQI above threshold, timeout was stopped. PQI test was not set in the app. Packet received.



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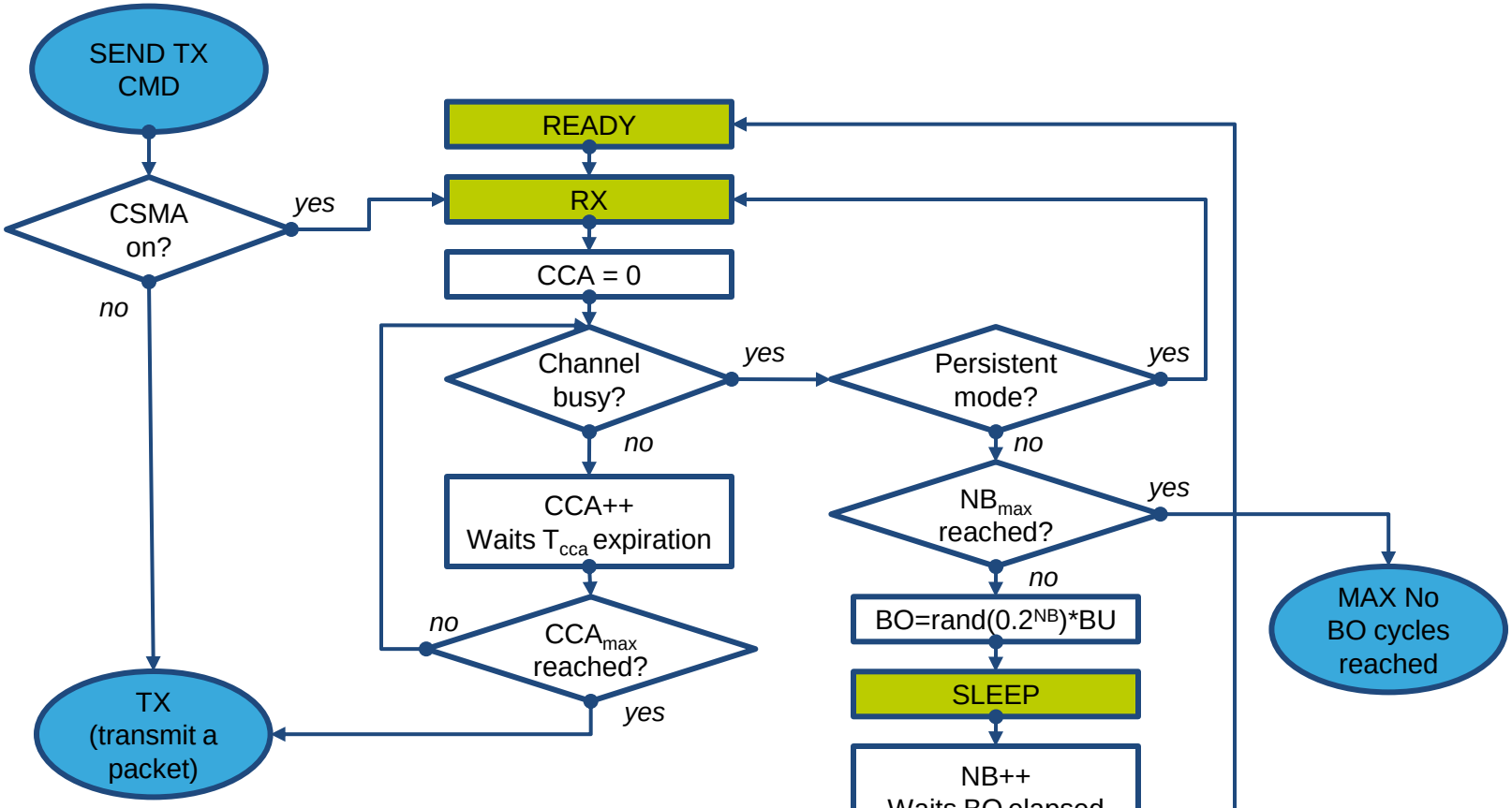
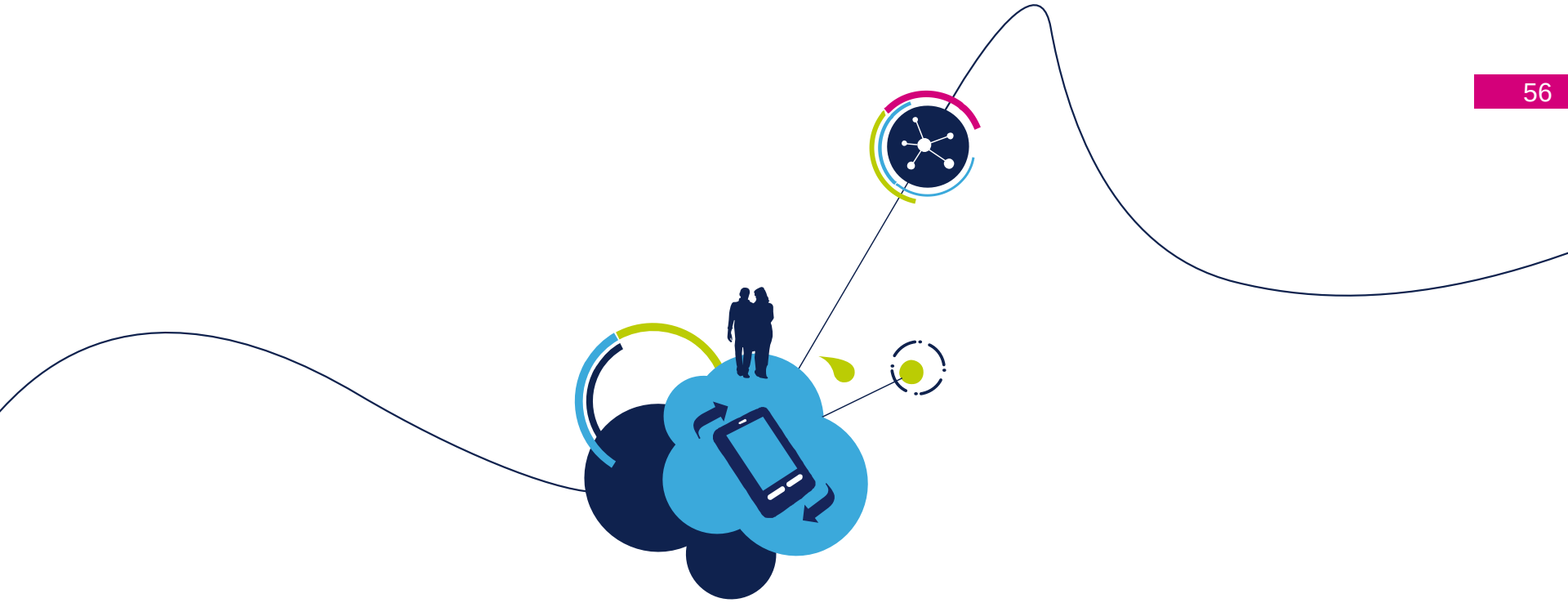
SPIRIT1 CSMA/CA Engine

The CSMA/CA engine is a channel access mechanism based on the LBT rule "listen before talk". This avoids the simultaneous use of the channel by different transmitters



Clear Channel Assessment (CCA)

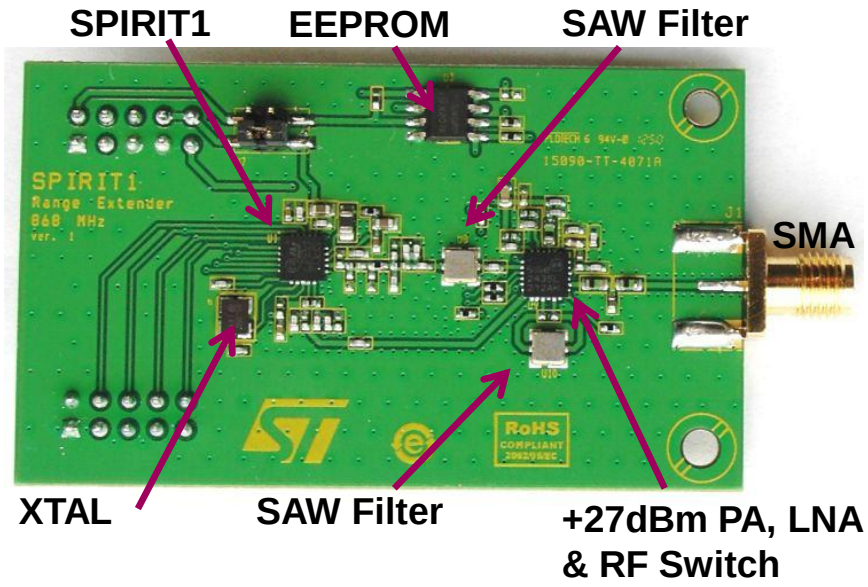


SPIRIT1 @ 868MHz with external PA for +27dBm Output Power

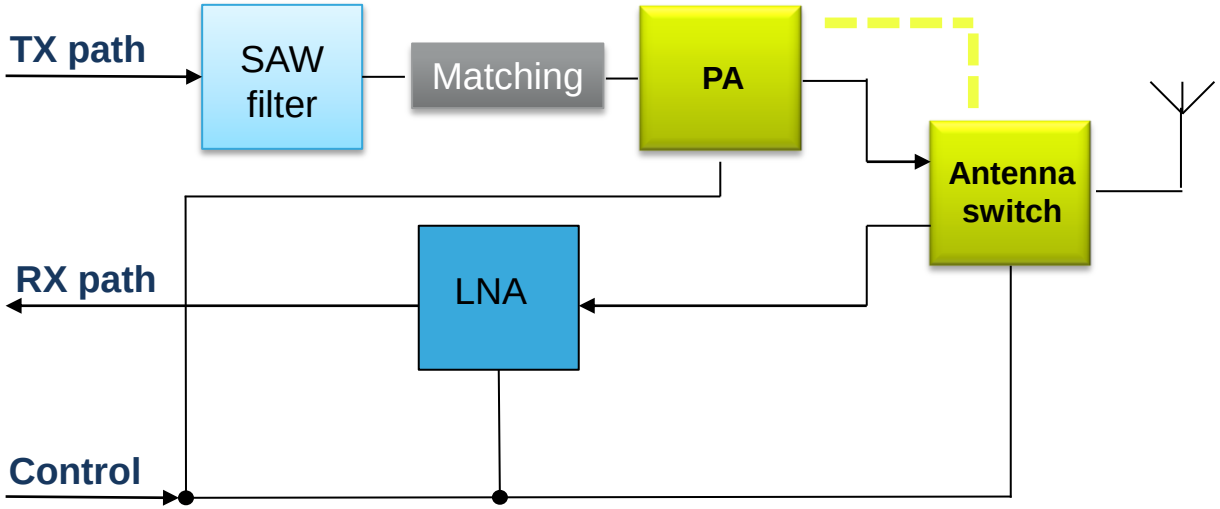
STEVAL-IKR001V8D

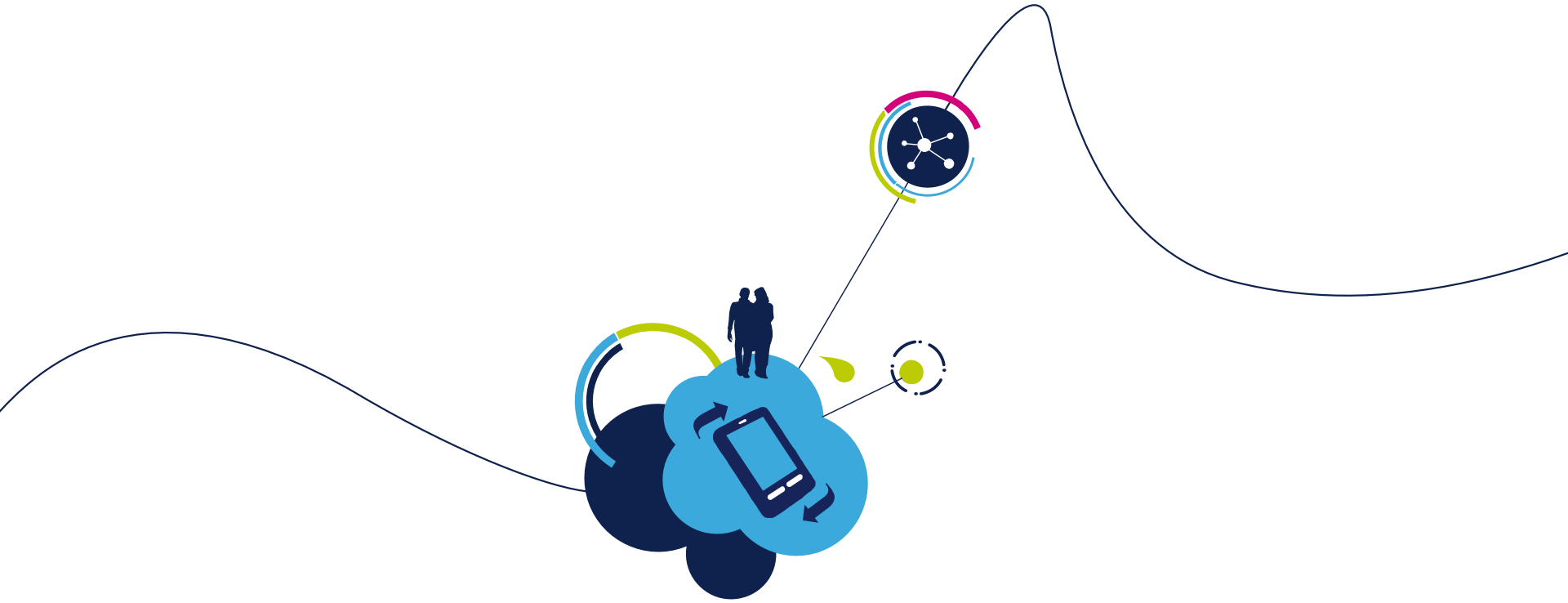
SPIRIT1 @868MHz with +27dBm output

- **STEVAL-IKR001V8D demo kit RF board content**
  - SPIRIT1 RF transceiver
  - Tai-Saw Technology – TA801A 868 MHz SAW filter
  - FEM (PA + LNA + RF Switch) - Skyworks SE2435L
  - EEPROM – M95640



PA = Power Amplifier
LNA = Low Noise Amplifier
SAW = Surface Acoustic Wave (selective filter)
FEM = Front End Module





SPIRIT1 Development Kit
Software Package

SPIRIT1 Development Kit content [1/3]

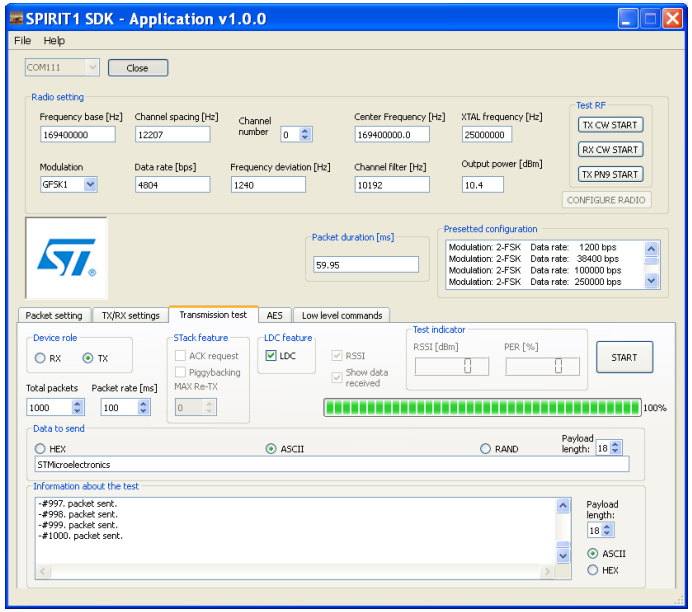
- SPIRIT1 Library (STM32L, STM8L)
  - Spirit1 low level drivers: APIs to manage the features the device offers (platform independent
    - Radio, GPIO, IRQ, Calibration, CSMA etc.
  - SDK_EVAL Libraries: APIs to manage the main features of the motherboard
  - Examples: BasicGeneric, LDCGeneric, StackGeneric, …
- WMBUS Library (Binary for STM32L)
  - library files with the PHYSICAL and LINK layer of the WMBUS STACK
  - Examples: The example has four configurations to differentiate between these combination : 169 or 868 bands and meter or concentrator
- SPIRIT1 SDK Virtual Com port
  - VirtualCom Libraries for the STM32L motherboard.
- MCU Standard Peripheral Library
  - standard peripheral library for the STM32L + STM8L microcontroller
- STM32 USB-FS-Device Library:
  - USB library for STM32L microcontroller

SPIRIT1 Development Kit content [3/3]

SPIRIT1 SDK Suite GUI

- SPIRIT1 SDK contains PC application (GUI) allowing:
  - Radio configuration
  - RF tests (TX of unmodulated carrier, TX PN9 sequence, RX activation)
  - Packet transmission/reception test with PER evaluation
  - AES engine encryption/decryption tests
  - Register read/write and dump
  - Store/load radio and packet configuration
  - Automatic Firmware Upgrade
  - Windows XP, 7

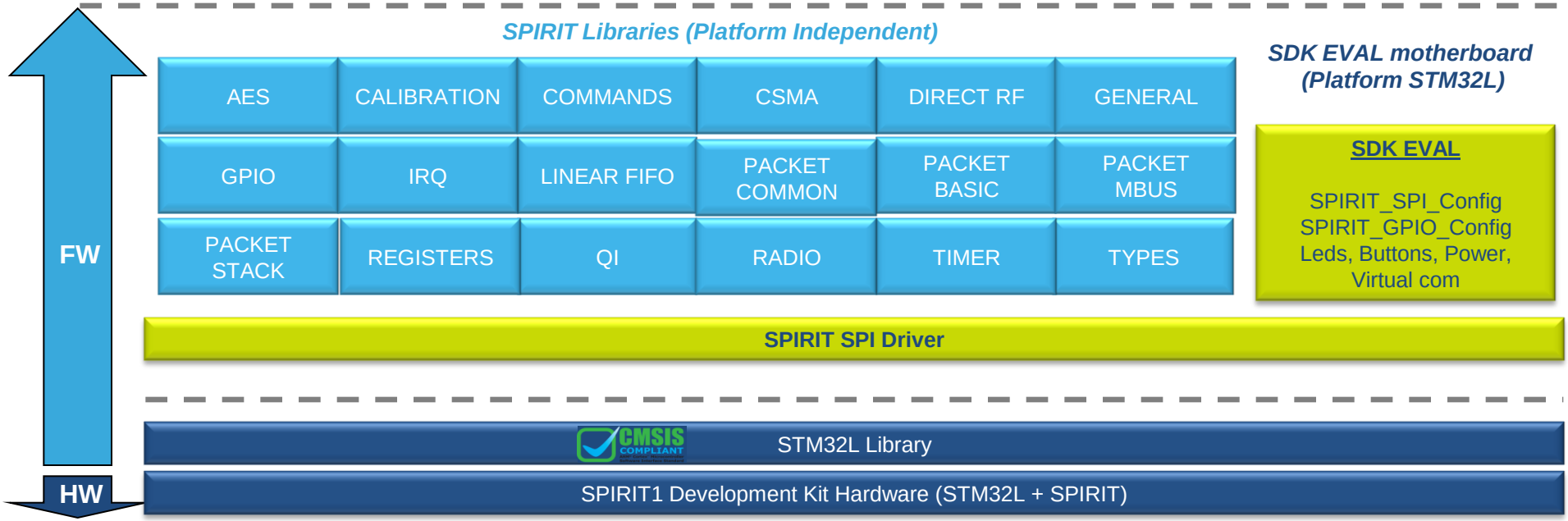
SPIRIT1 RF performance evaluation



STM32L SPIRIT1 SDK Firmware Package Architecture

The firmware package of the Spirit Development Kit provides in addition to the SPIRIT1 Library:

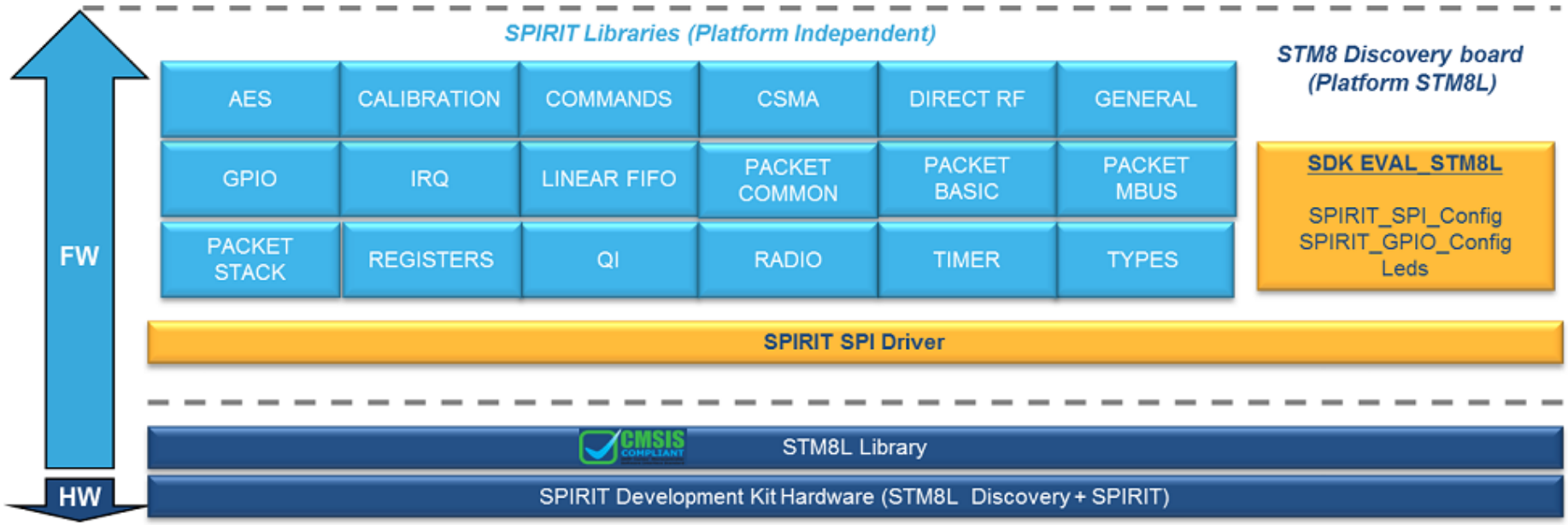
- SDK Eval: a set of API functions to manage the motherboard of the SDK (STM32L microcontroller) including USB library and DFU project files for firmware upgrade
- STM32L library: the standard peripheral library for the STM32L microcontroller.
- SPIRIT1 Examples: BasicGeneric, LDCGeneric, StackGeneric etc.
- Developed under EWARM IAR v.6.40 IDE (ST-Link, J-Link required for debugging)



STM8L SPIRIT1 SDK Firmware Package Architecture

The firmware package of the Spirit Development Kit provides in addition to the SPIRIT1 Library:

- SDK Eval: a set of API functions to manage the STM8L discovery board (STM8L microcontroller) STM8L library: the standard peripheral library for the STM8L microcontroller.
- SPIRIT1 Examples: BasicGeneric, LDCGeneric, StackGeneric etc.
- Developed under EWARM IAR v.6.40 IDE (ST-Link, J-Link required for debugging)



STM8L Firmware architecture

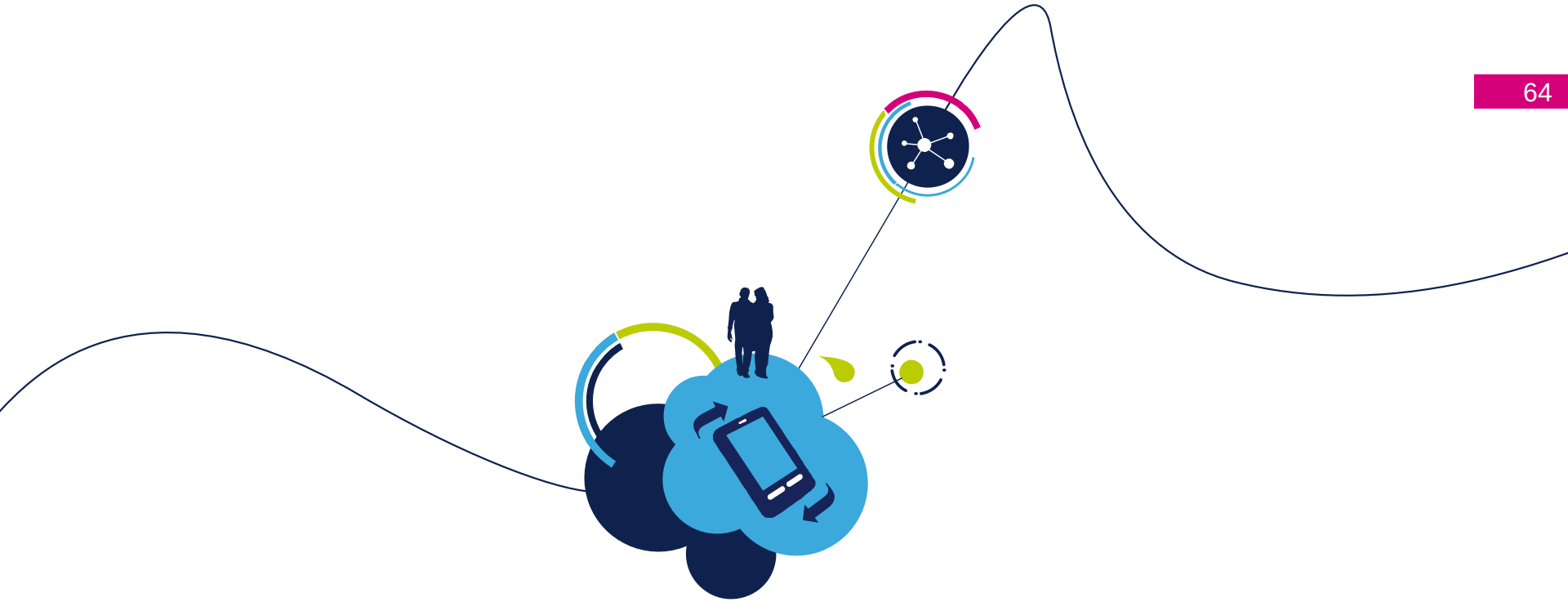
SPIRIT1 library Memory Foot print STM32L

	Flash (KBytes)	Ram (Bytes)
SPIRIT1 Library (on STM32L)	20	28

- Maximum usage using all the driver features (Typical application will use much lower flash, e.g 4K)
- Preliminary data

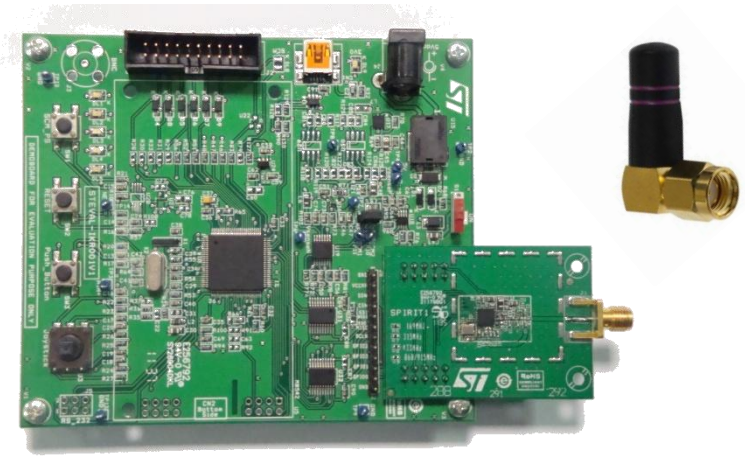
	Flash (KBytes)	Ram (Bytes)
WM-BUS protocol stack	9.1	2148

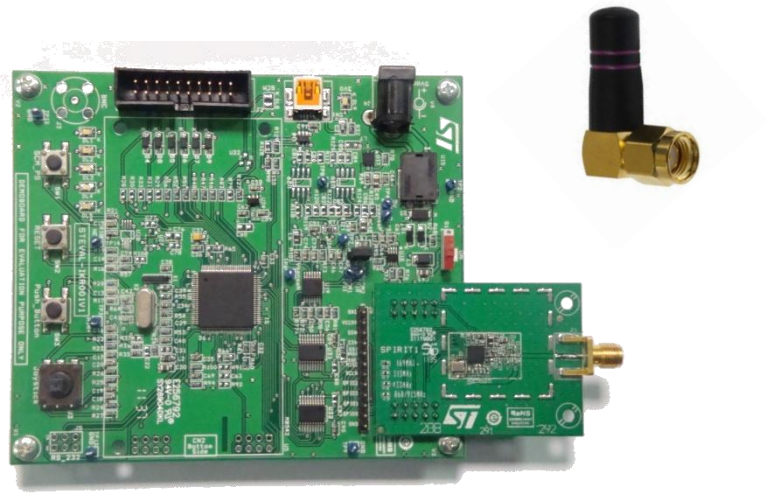
- Maximum usage of the Wireless M-Bus library
- Both data are reffered from libraries in SPIRIT1 Dev Kit version 1.0.6 compiled with IAR with high optimization on the code size



Getting Started with the SPIRIT1 Development Kit (DK)

SPIRIT1 DK content





SPIRIT1 Development Kits

STEVAL-IKR001V1 – 169 MHz

STEVAL-IKR001V2 – 315 MHz

STEVAL-IKR001V3 – 433 MHz

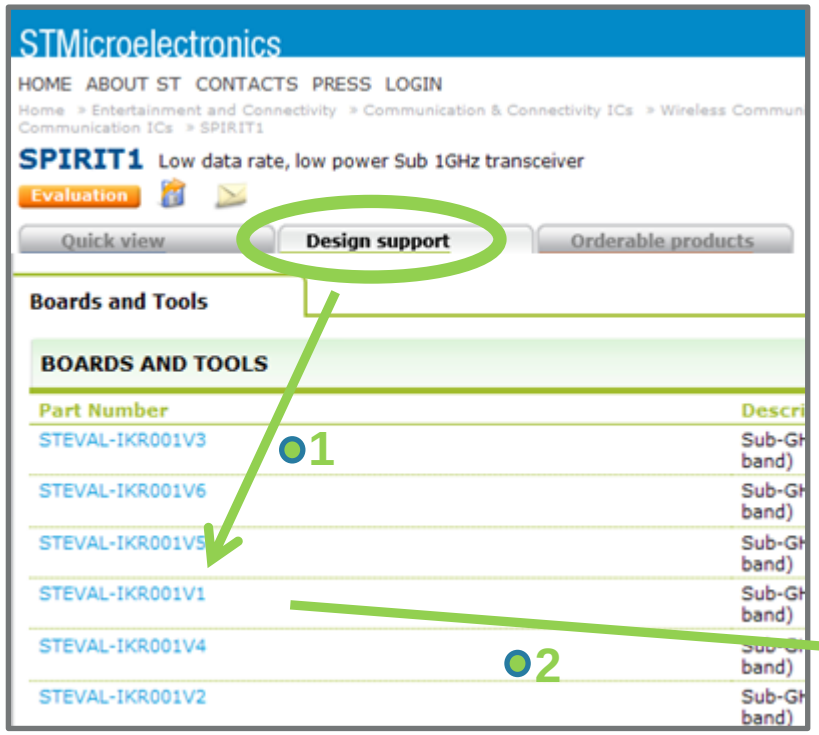
STEVAL-IKR001V4 – 868MHz

STEVAL-IKR001V5 – 915 MHz

STEVAL-IKR001V6 – 920 MHz

***DK – Development Kit**

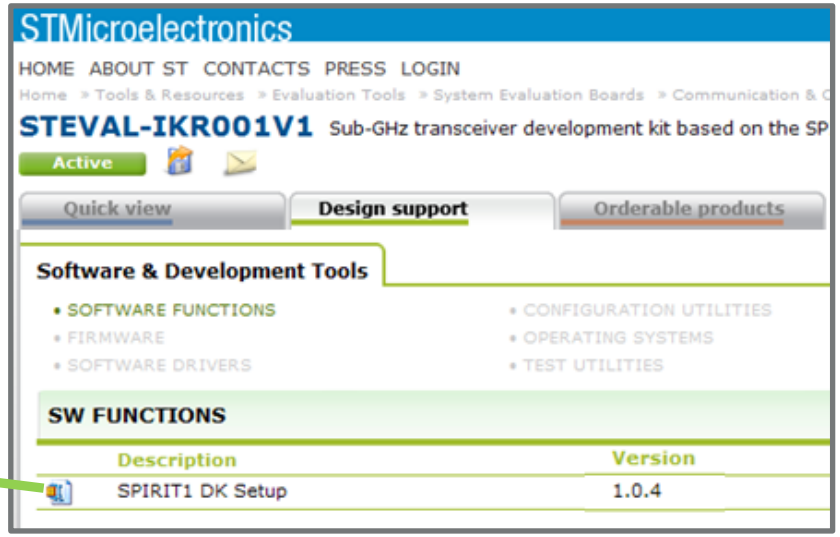
SDK Download



- **Go to SPIRIT1 website**

http://www.st.com/internet/imag_video/product/253167.jsp

- **Under Design Support TAB 1 click on the link of the board you have,**
  - **i.e. STEVAL-IKR001V1 2**

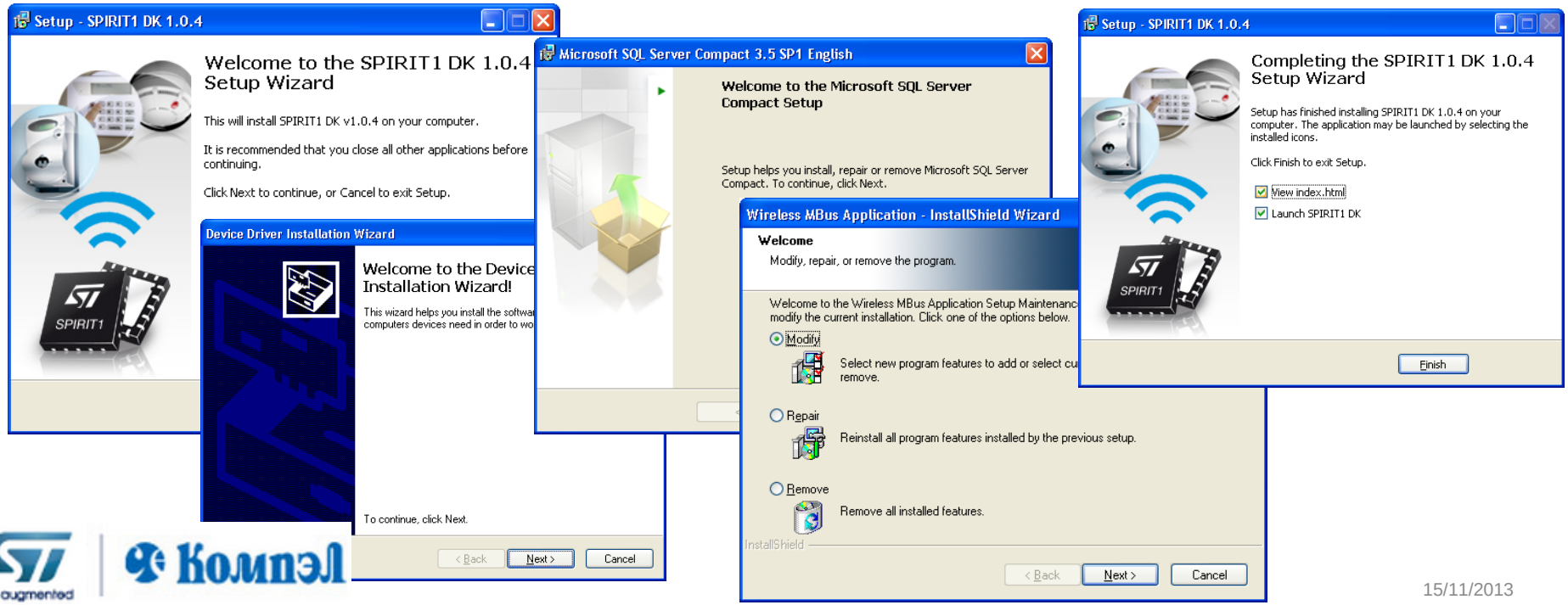


- **In the Design Support TAB click download and install the latest SPIRIT1 DK Setup 3**

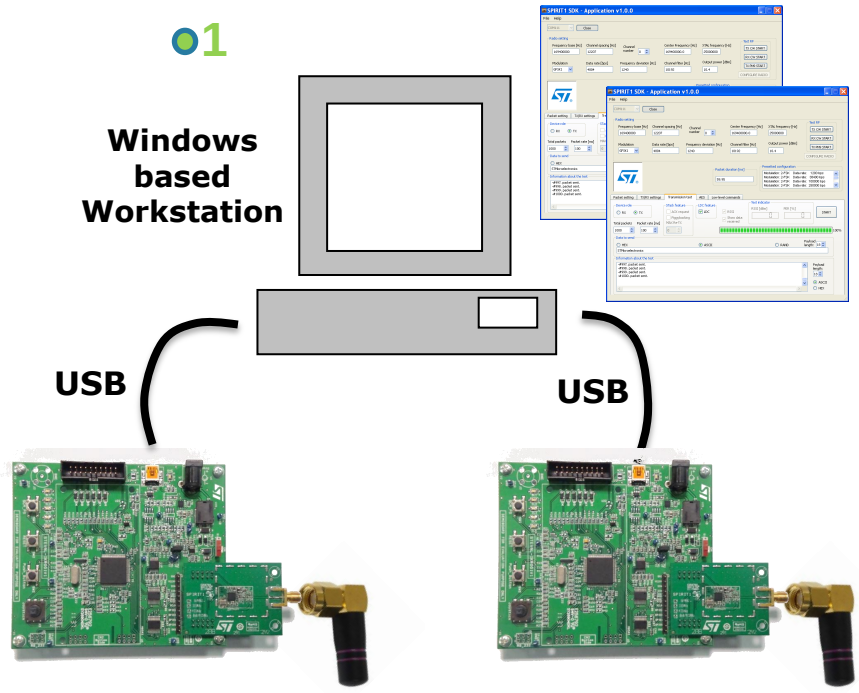
***SDK – Software Development Kit**

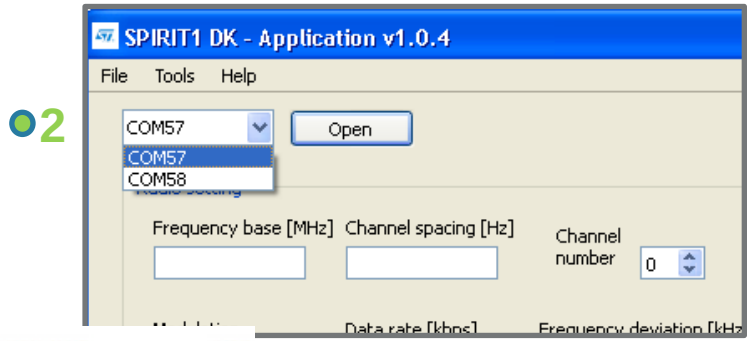
SDK installation

- **Run the SPIRIT1 DK-Setup-1.0.x.exe downloaded from www.st.com**
  - **Follow the instruction given in the dialog box**
  - **You will be prompted to accept device driver installation (VCOM driver). Click next and follow the instructions to install it**
  - **Microsoft SQL Server Compact installation will be started automatically. Proceed with the installation in case you want to use the W-Mbus (optional)**
  - **Finally, accept to install the W-Mbus Application (optional)**

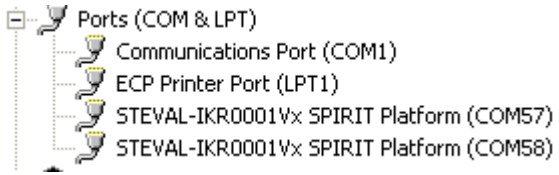

Setup - SPIRIT1 DK 1.0.4
Welcome to the SPIRIT1 DK 1.0.4 Setup Wizard
This will install SPIRIT1 DK v1.0.4 on your computer.
It is recommended that you close all other applications before continuing.
Click Next to continue, or Cancel to exit Setup.
Device Driver Installation Wizard
Welcome to the Device Installation Wizard!
To continue, click Next.
< Back
Next >
Cancel
Microsoft SQL Server Compact 3.5 SP1 English
Welcome to the Microsoft SQL Server Compact Setup
Setup helps you install, repair or remove Microsoft SQL Server Compact. To continue, click Next.
Wireless MBus Application - InstallShield Wizard
Welcome
Modify, repair, or remove the program.
Welcome to the Wireless MBus Application Setup Maintenanc
modify the current installation. Click one of the options below.
Modify
Select new program features to add or select cu
remove.
Repair
Reinstall all program features installed by the previous setup.
Remove
Remove all installed features.
InstallShield
< Back
Next >
Cancel
Setup - SPIRIT1 DK 1.0.4
Completing the SPIRIT1 DK 1.0.4 Setup Wizard
Setup has finished installing SPIRIT1 DK 1.0.4 on your computer. The application may be launched by selecting the installed icons.
Click Finish to exit Setup.
View index.html
Launch SPIRIT1 DK
Finish

HW & SW set-up





- **Connect both STM32L motherboards to the PC** 1
- **Check the device manager, two devices with different VCOM numbers should be visible**



- **Run two instances of the SPIRIT1 DK GUI (Start -> Programs-> STMicroelectronics -> SPIRIT DK_1.0.x -> SPIRIT1 DK)**
- **In each SPIRIT1 DK GUI, select one of the COM ports** 2
  - **Click Open port in both GUIs -> you are ready to test SPIRIT1**

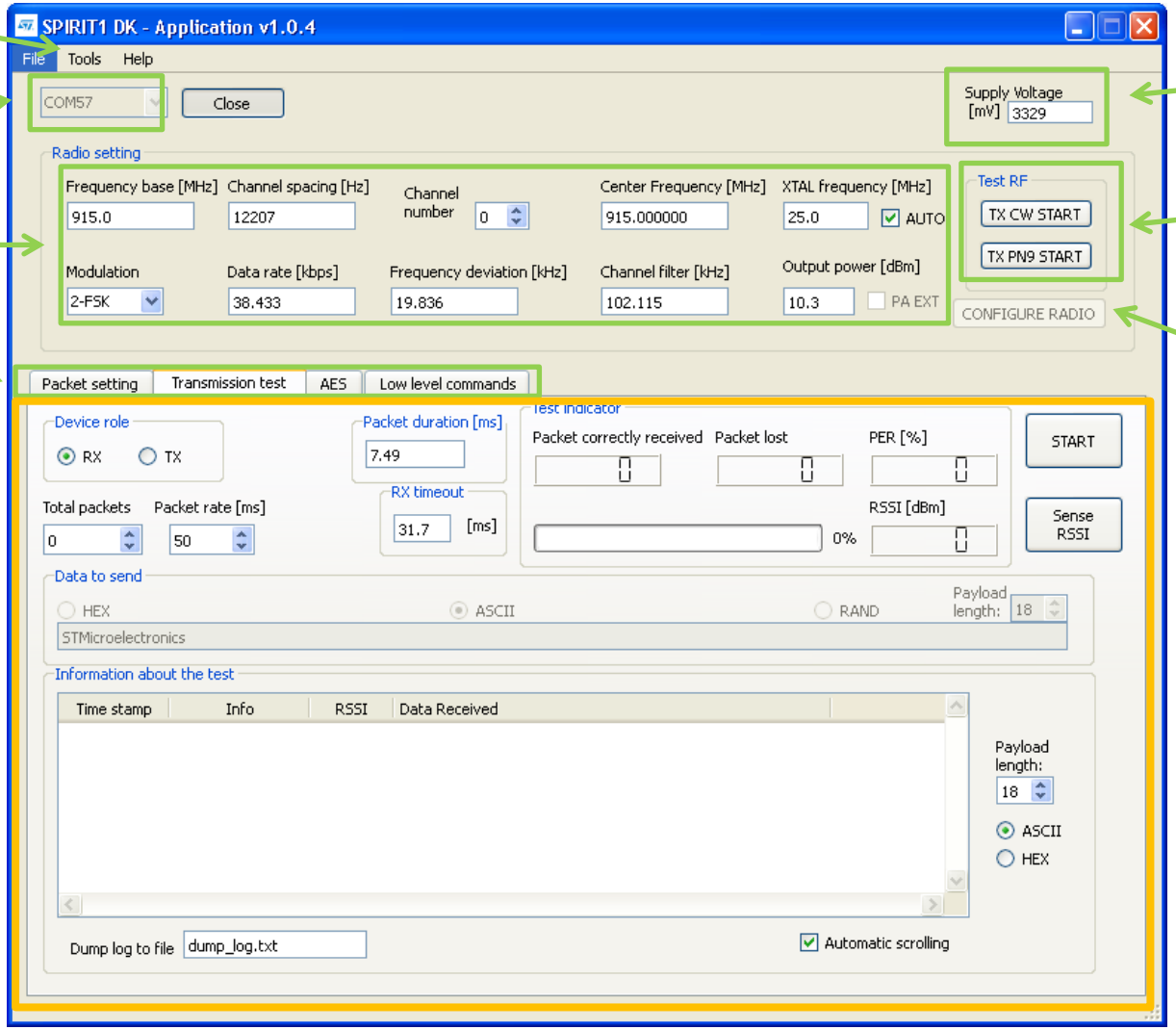
SPIRIT1 DK GUI - 1/5

Tools, firmware flasher

Connection panel COM port

Radio settings

Non-RADIO SPIRIT1 set-up, register access, Communication test



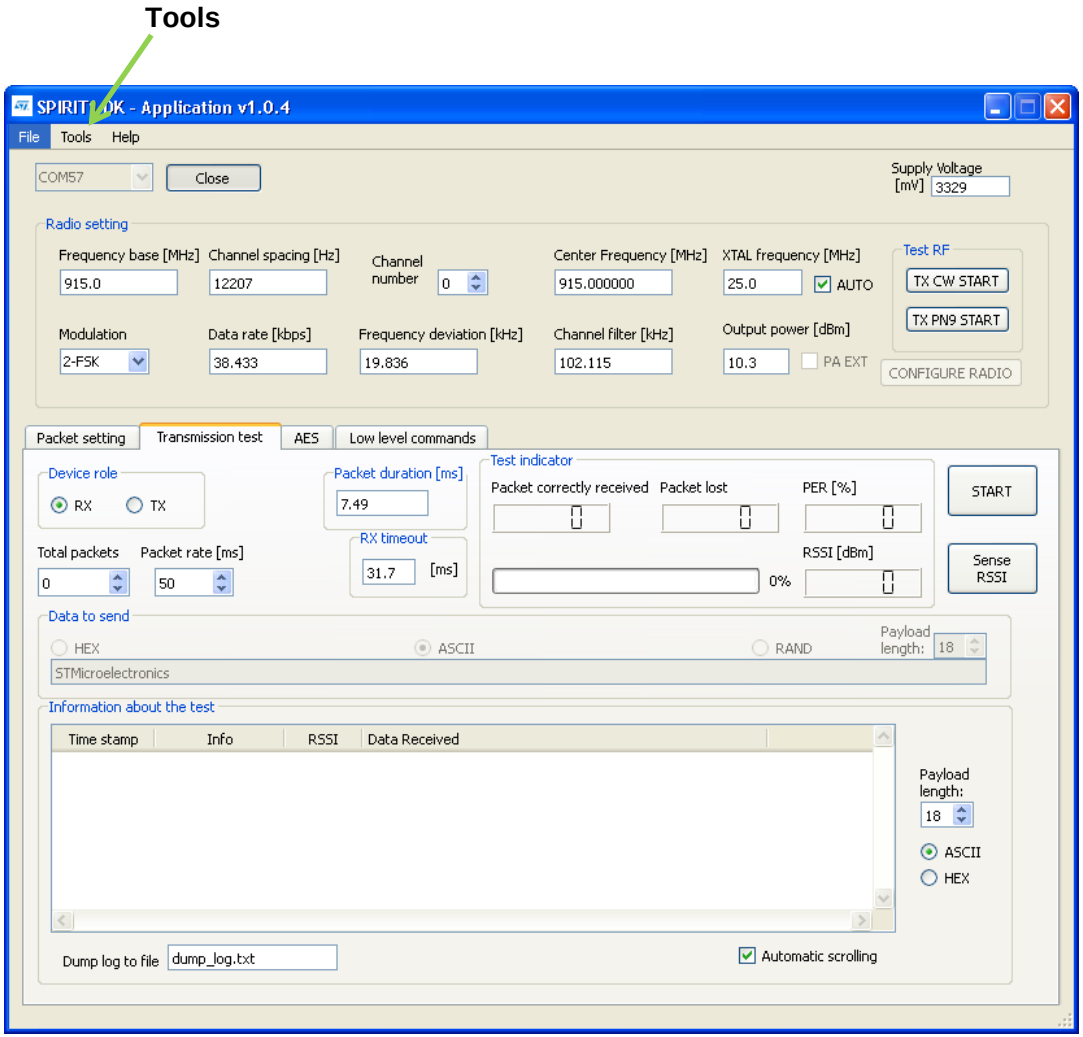
SPIRIT1 supply voltage

Test RF – generates Carrier Wave or pseudorandom binary sequence

Click CONFIGURE RADIO button when you change any Radio settings

Details on next slides

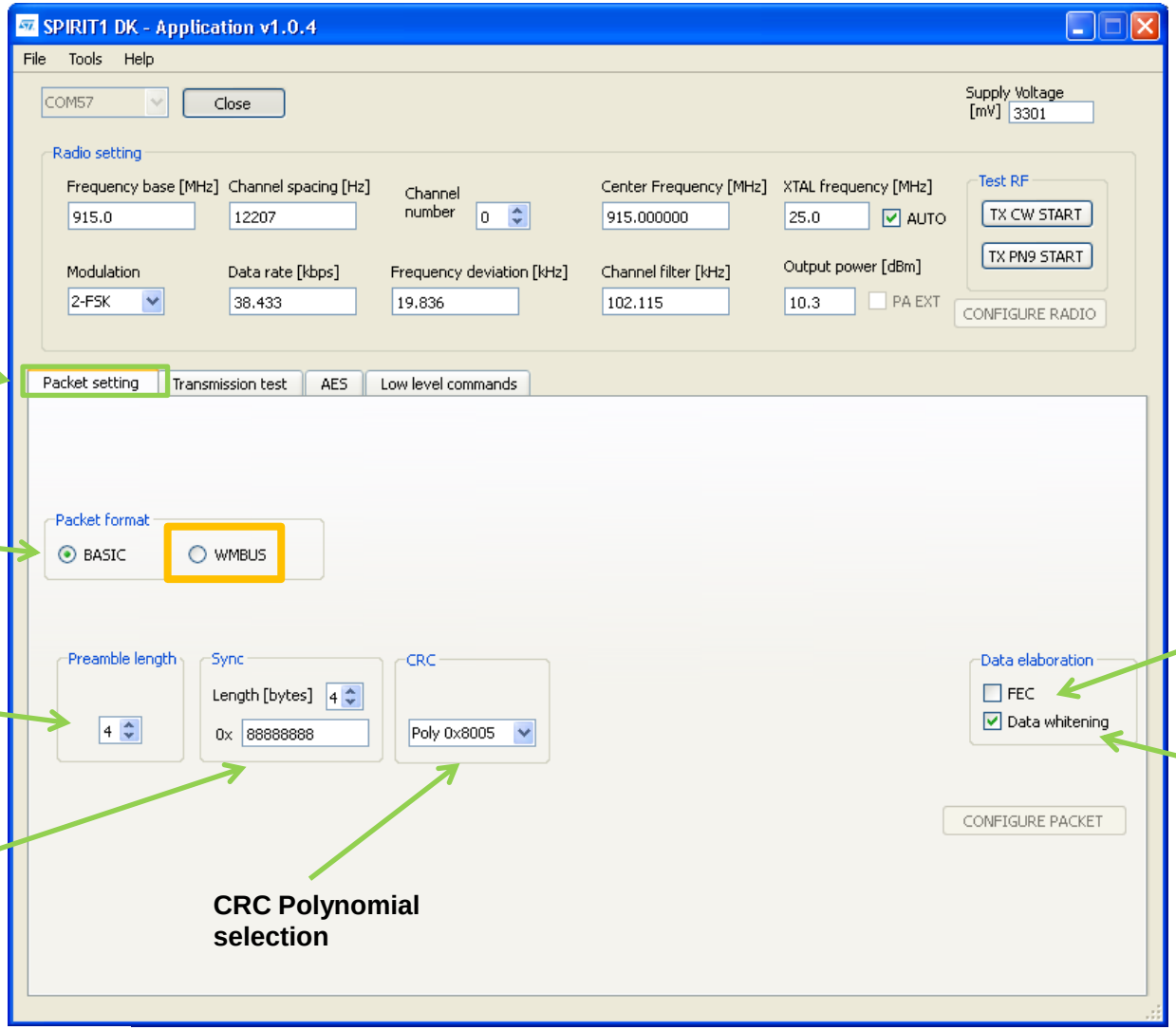
SPIRIT1 DK GUI - 2/5



Tools

- **Firmware Upgrade**
  - Uses DFU boot loader (read details in the board user manual about how to put DK board in the DFU mode)
- **Firmware Version**
  - Reads the board firmware version, in case it does not correspond to the DK GUI version, it is recommended to flash the corresponding one (you can find it at …\Firmware\Binary file\SPIRIT1_DK.hex) - Firmware Upgrade
- **Save the Current Configuration**
  - Stores the SPIRIT1 DK GUI configuration you made
- **Load the Saved Configuration**

SPIRIT1 DK GUI - 3/5



Packet Setting

Packet Format

Preamble Length; 1 – 32 Bytes

Sync Word, Length (1- 4 Bytes)

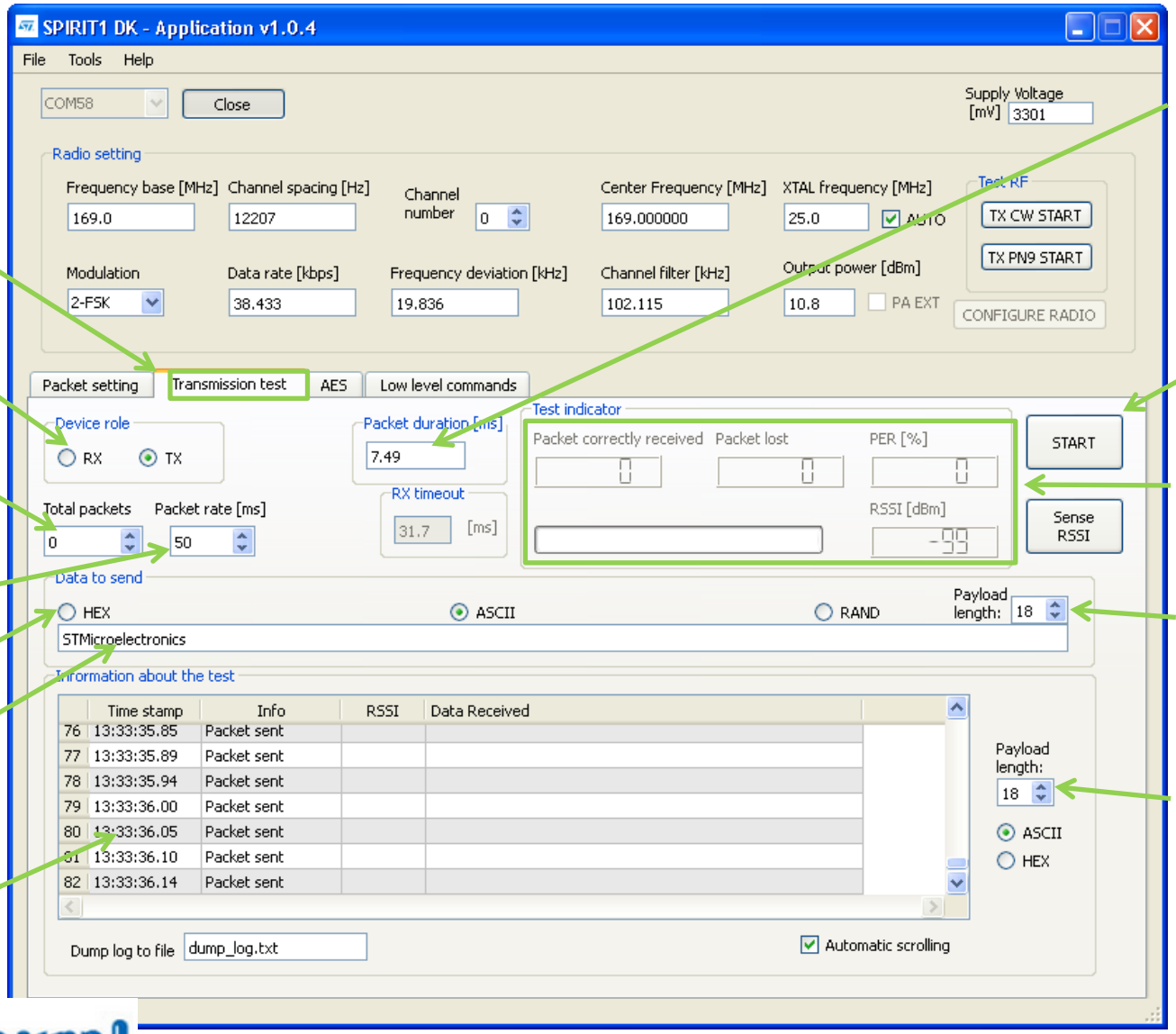
CRC Polynomial selection

Forward Error Correction

Data Whitening

Similar for WMBUS packet format

SPIRIT1 DK GUI - 4/5



Transmission Test

Select the device Role (different for each board)

Number of packets to transmit (0 = infinite nbr)

Packet rate; set the same for TX and RX role

Payload data format

Payload data for transmitting

Overview of the received or transmitted packets

Packet duration – calculated from the data rate and number of bytes transmitted

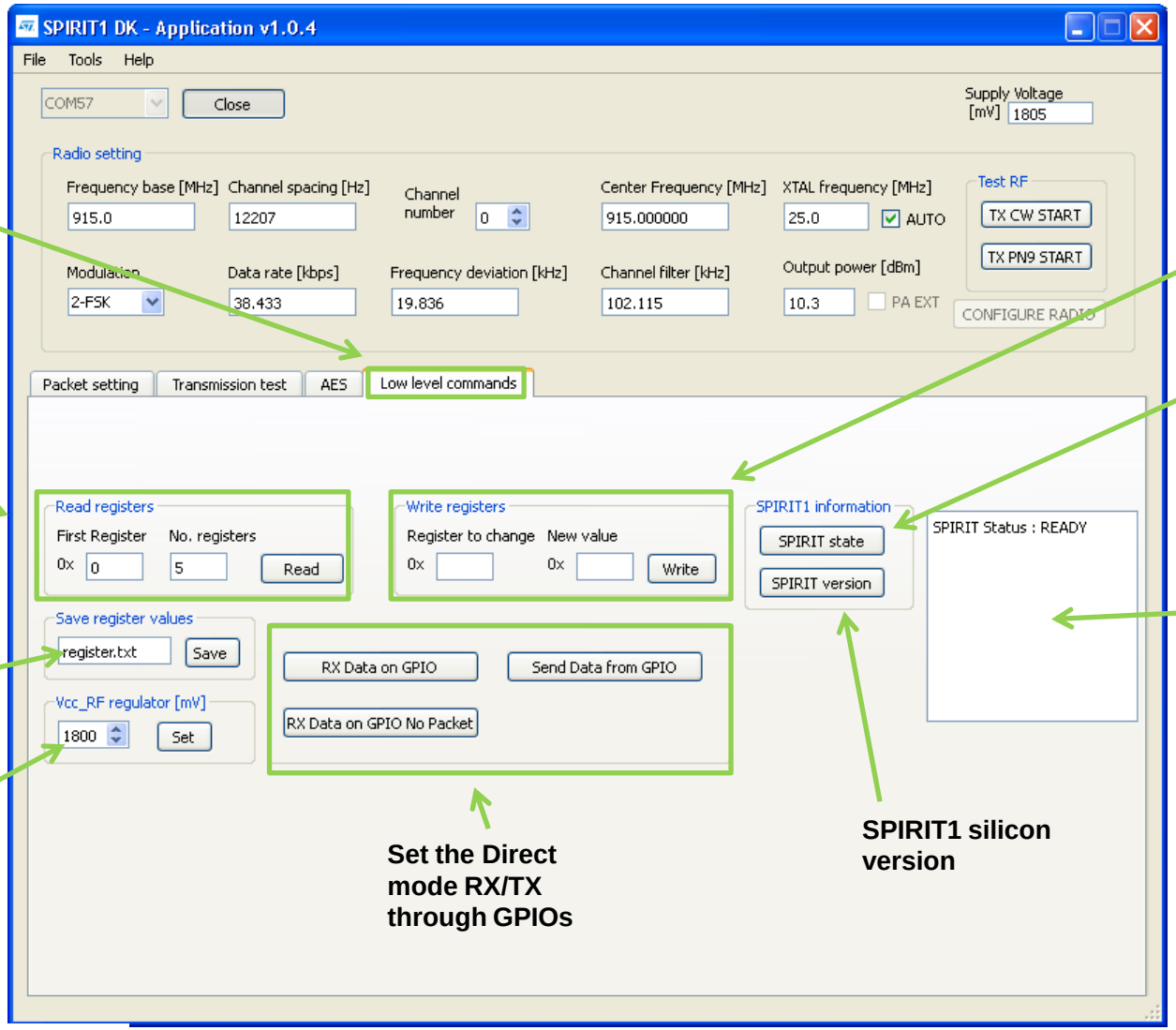
Start Receiving or transmitting

Packet Error Rate Statistic

Number of Bytes to send as payload

Number of Bytes expected in the receiver

SPIRIT1 DK GUI - 5/5



Low level Commands

Read the register content

Save register content (e.g. to copy it to your C code)

Set the supply voltage (1.8 – 3.4V)

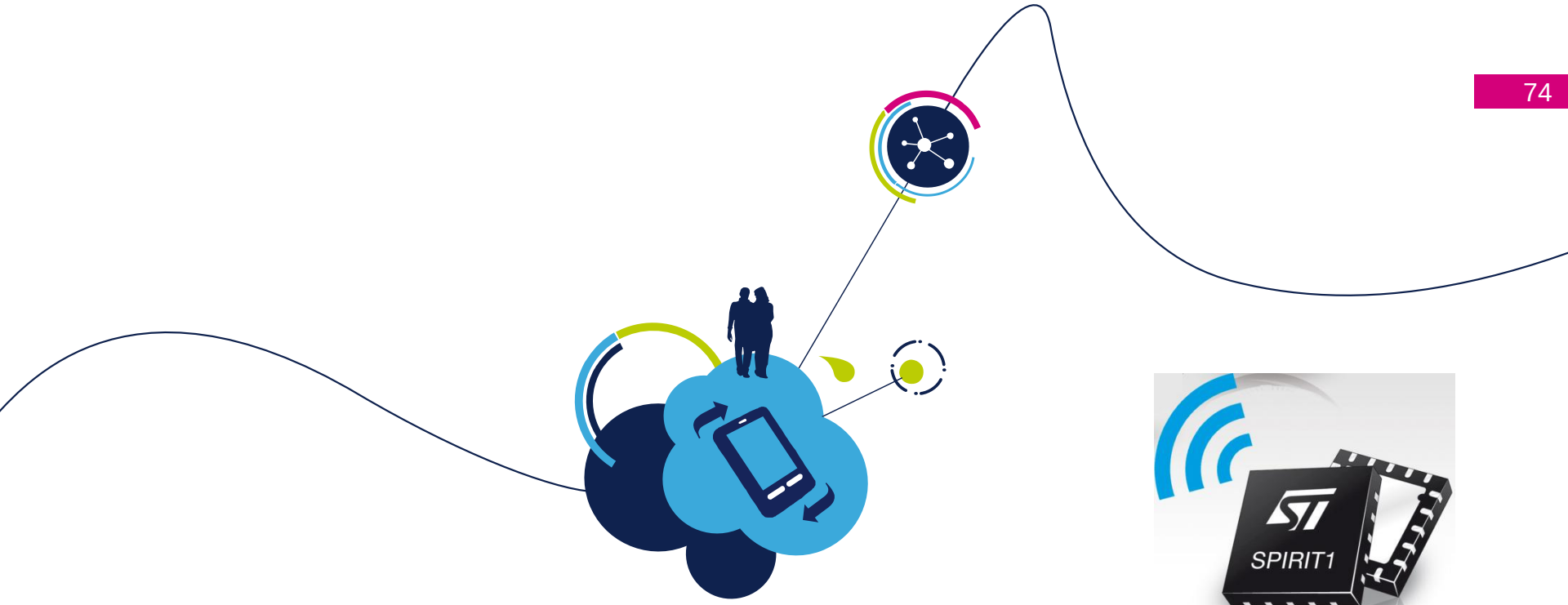
Write any particular register

Reads the current state of SPIRIT1

Information block

Set the Direct mode RX/TX through GPIOs

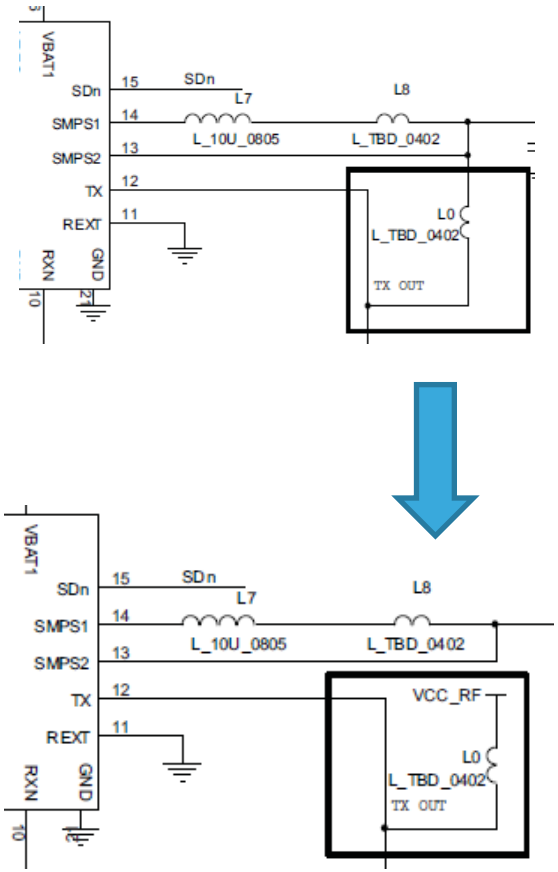
SPIRIT1 silicon version



SPIRIT1 Application Hints

AN4198: Increasing the radiated Output Power up to +16dBm

- In the default configuration the transmitter internal power amplifier output (pin 12) is biased by the 1.4V SMPS voltage output through the L0 external inductor



- Biasing the PA output through the inductor L0 directly connected to the battery, instead of the SMPS output allows to increase the maximum output power delivered to the antenna

- Example

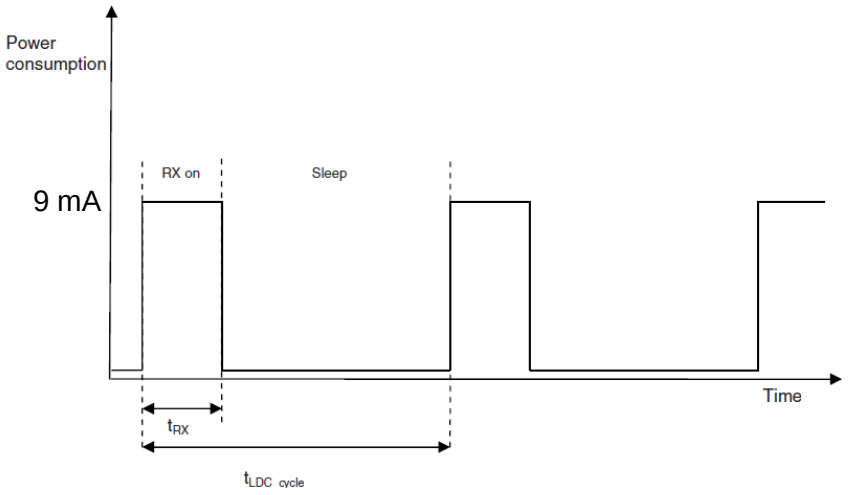
Table 1. 170 MHz maximum output power and current consumption

Voltage supply V_{BAT}	Maximum output power (measured at connector)	Current consumption (TX mode)
3.6 V	+16.1 dBm	54 mA
3.0 V	+15.6 dBm	51 mA
2.4 V	+14.8 dBm	44 mA
1.8 V	+13.0 dBm	27 mA

AN4193: Low duty cycle operation with SPIRIT1 transceiver [1/X]

Why?

- To reduce average power consumption during RX and TX operation
- To build a synchronized star network where both transmitter and receiver can sleep periodically to reduce average power consumption
- LDC mode is controlled by two timers:
  - The LDC timer which defines the window where the duty cycle operation take place ($t_{LDC\ CYCLE}$)
  - The RX_TIMEOUT timer which defines the amount of time that the receiver is active (t_{RX})



$t_{LDC\ CYCLE}$ – max. 2s, granularity 29µs

$$RX_{consumption\_average} = \frac{t_{RX}}{t_{LDC\_cycle}} \cdot 9 + \frac{t_{LDC\_cycle} - t_{RX}}{t_{LDC\_cycle}} \cdot 0.00085\ mA$$

RX current

Sleep current

How to define t_{RX} ?

AN4193: Low duty cycle operation with SPIRIT1 transceiver [2/X]

How to define t_{RX} ?

- RX timeout using the Sync detection
  - When valid Sync is detected, we are receiving a valid data packet
  - RX timeout is stopped when a valid SYNC word is detected and the receiver is expected to receive a complete packet

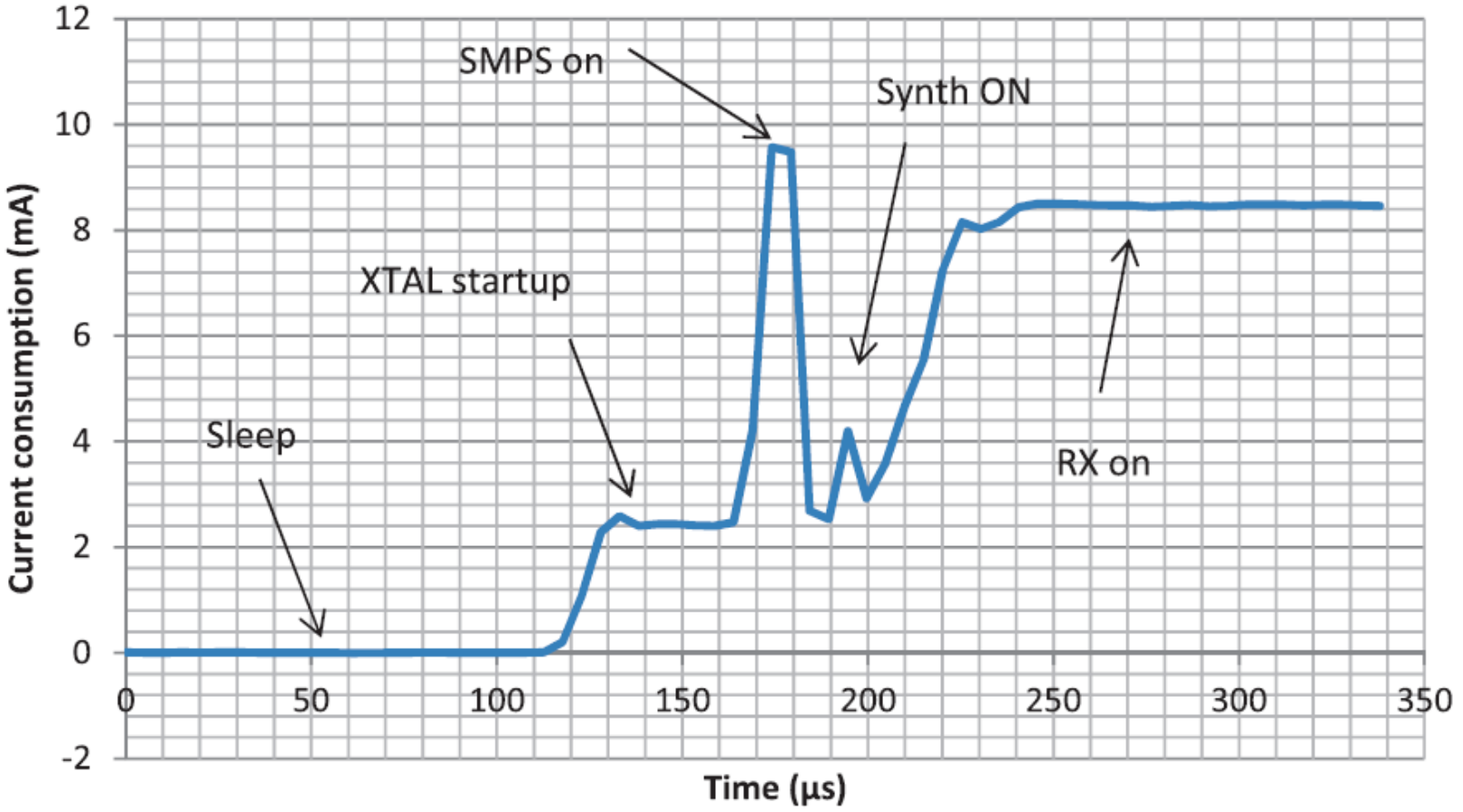
Preamble	Sync	Length	Dest. address	Source address	Control	Seq. No.	NO_ACK	Payload	CRC

STack packet format

- RX timeout using the RSSI detection
  - RX timeout is stopped upon detection of signal energy above a certain user defined threshold
  - This mode will further reduce average power consumption by decreasing the time when receiver must be on. On the other hand the MCU needs to check that a valid message is received within a user defined timeout.
  - The time to measure RSSI of the incoming signal will vary according to the RX filter bandwidth

RX filter min (kHz)	RX filter max (kHz)	RSSI detection time (µS)
4.2	7.0	1800
7.0	14.0	950
14.0	28.0	550
28.0	56.1	346
56.1	112.3	280
112.3	224.7	175
224.7	450.9	90
450.9	800.1	34

AN4193: SPIRIT1 Current consumption profile during wake up to RX



Wireless M-BUS Solutions

STM32L & SPIRIT1

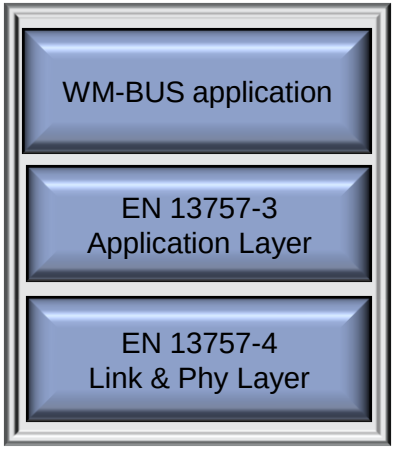
life.augmented

What is Wireless M-BUS ?

- Open standard for Automatic Meter Reading at sub 1 GHz
- Metering Bus (or in short "M-Bus ") is a basis for new advanced metering infrastructure (AMI) installations. It defines the communication between meters for water, gas, heat and the data concentrators.
- Wireless M-Bus standard defines the wireless communication between meters.

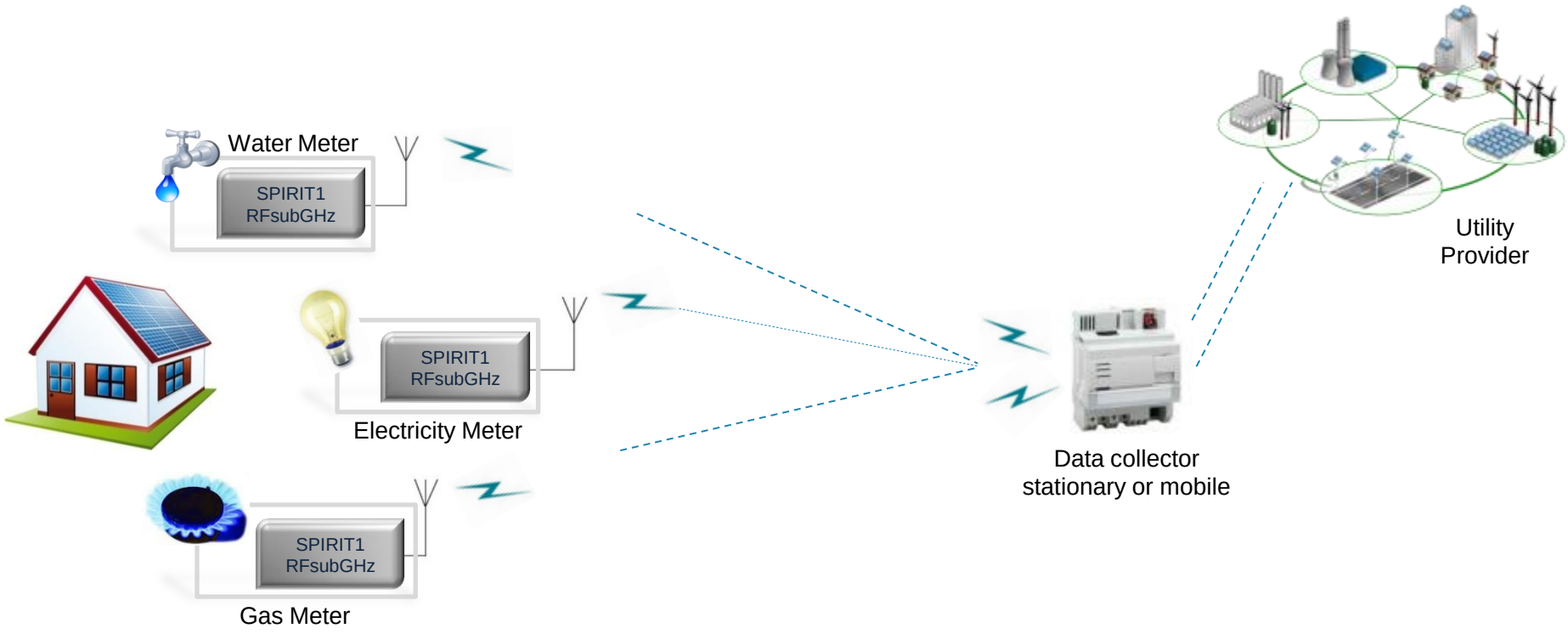
Relevant standards documents are:

- European standard prEN13757-4:2011 Wireless meter readout
- European standard EN13757-3:2004 Dedicated application layer
- ETSI EN 300 220 v2.3.1



Wireless M-BUS
protocol stack

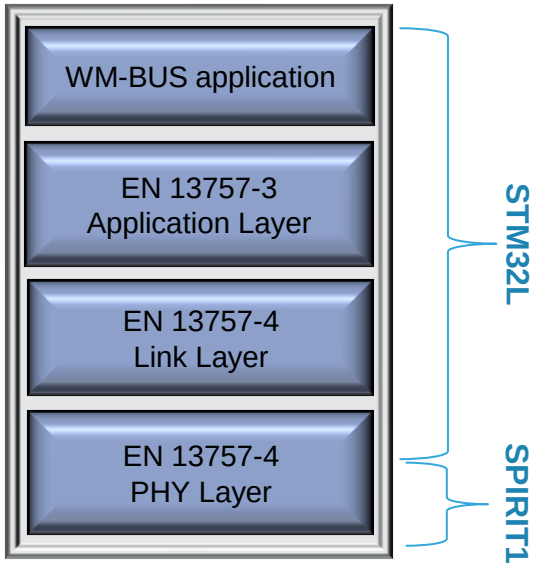
Wireless M-BUS scenario



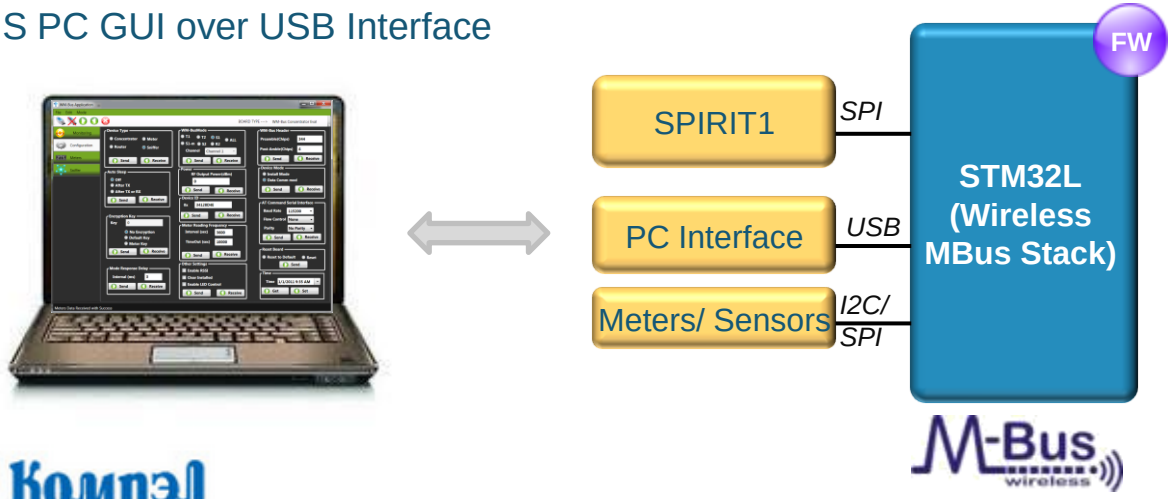
- Automatic meters reading to:
  - Stationary data collectors
  - Mobile data collectors
- Meters are working without any operator's intervention or need for battery replacement

ST Wireless M-BUS Stack features (1/2)

- Development based on:
  - STM32L152 MCU ARM 32bit
  - SPIRIT transceiver SubGHz
- WMBUS protocol stack EN113757-4:2011.10
- Mode supported are: S, T, R, N
  (except N2g which requires 4-GFSK modulation)
- Device Type: Meter and Concentrator
  →PHY and LINK layer implementation provided as binary library for ARM Cortex-M3 (STM32L).
  →Example application layer provided in source code form for user customization.
  Sniffer Type *under development*
- WMBUS PC GUI over USB Interface



Wireless M-BUS protocol stack



ST Wireless M-BUS Stack features (2/2)

WMBUS Mode supported are:

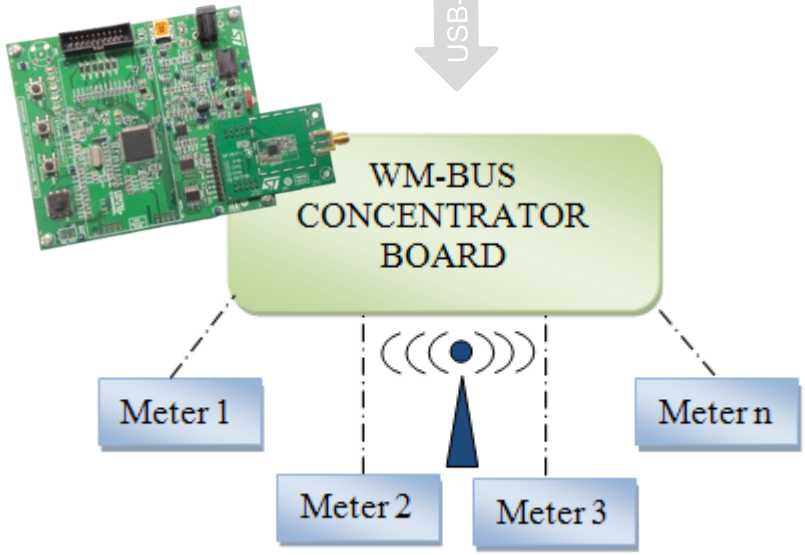
→S, T, R @ 868Mhz

→N @ 169MHz

(except N2g which requires 4-GFSK modulation)

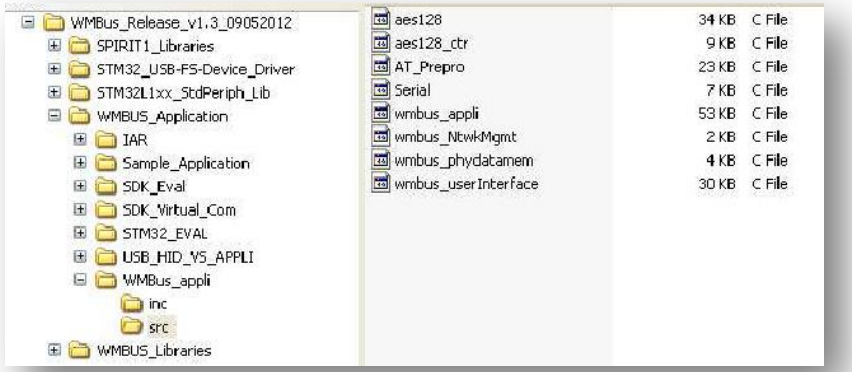
Main features are:

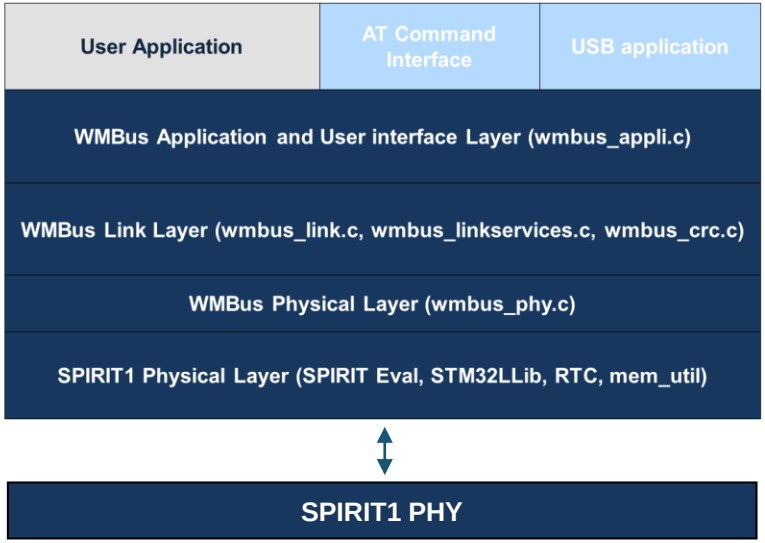
- Auto acknowledgment
- CRC check
- Installation mode/data mode
- Management of a simple meter database based on linked list
- Packet filtering based on registered meters
- Meter and Other roles
- Non blocking API
- AES CTR support
- AT Command (under development)



STM32L WM-BUS Firmware library

- **wmbus_appli.c**
  - Application layer provided as an example in source code
- **wmbus_link.c**
  - Link layer provided in library format
- **wmbus_phy.c**
  - PHY layer provided in library format




User Application
AT Command Interface
USB application
WMBus Application and User interface Layer (wmbus_appli.c)
WMBus Link Layer (wmbus_link.c, wmbus_linkservices.c, wmbus_crc.c)
WMBus Physical Layer (wmbus_phy.c)
SPIRIT1 Physical Layer (SPIRIT Eval, STM32LLib, RTC, mem_util)
SPIRIT1 PHY

MEM Footprint:

- 2.1K RAM, 9.1KBytes FLASH (IAR optimization high (size))
- 2.1K RAM, 18 K flash (not optimized)

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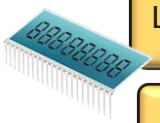
ST WM-BUS library LINK Layer APIs

Name	Description
WMBus_LinkGetAttribute	Read attribute from link layer
WMBus_LinkSetAttribute	Set attribute in link layer
WMBus_LinkServicesInit	Init the link service layer
WMBus_LinkServicesReset	Reset the link service layer
WMBus_LinkRadioPowerOn	Power on radio
WMBus_LinkRadioPowerOff	Power off radio
WMBus_LinkRadioStandby	Put the radio in standby
WMBus_LinkRadioResume	Resume radio from standby
WMBus_LinkServicesRequestsCallbackMode (…)	This function processes a request service primitive, generates a valid C-field by setting the FCV, FCB, and PRM bits, transmits the request frame, checks for confirm/response is applicable, and retries data transmission when appropriate (Send/Confirm, Request/Respond when valid ack/nack is not received).
WMBus_LinkServicesIndicationCallbackMode	Receive message within a specific timeout
WMBus_LinkServicesResponseCallbackMode	This function attempts to transmit the response to the indication frame received.

Gas Meter ref Design

Under Development

- STM32L162: 32bit MCU ARM CM3 ULP
- SPIRIT1: Sub GHz RF transceiver
- LIS3DH: Accelerometer for Earthquake
- M24LR64:DUAL EEPROM RFID/I2C
- M24M02: EEPROM
- M41T62: external RTC
- STTS751: Temperature Sensor
- Omron GAS Sensor



OMRON Flow Sensor

ON/OFF VALVE

I2C

GPIO

MEMS Earthquake LIS3DH

SPI

LCD Segment

IO

LSE RTC

32KHz Xtal

M24lLR64-R

I2C

STM32L162

RTC with calendar

LCD glass

Hw AES

UART

IrDA

SPI

SPIRIT1 Sub GHz RF (module)

I2C

EEPROM M24M02

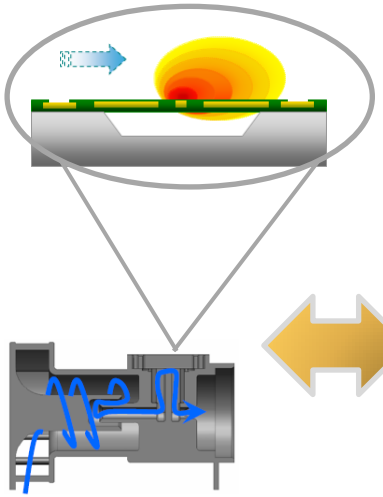
I2C

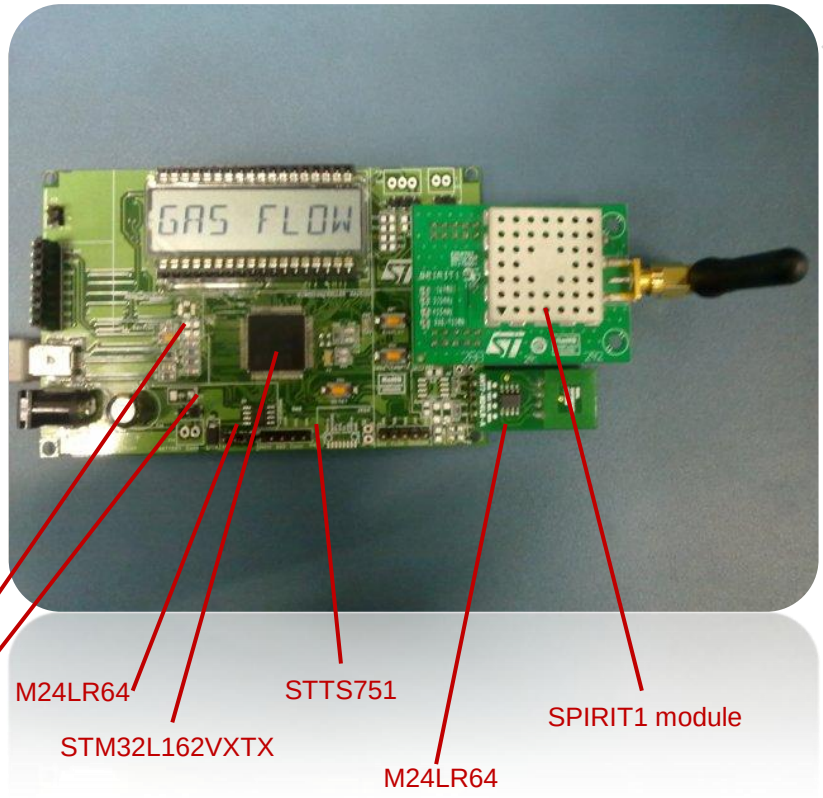
RTC M41T62

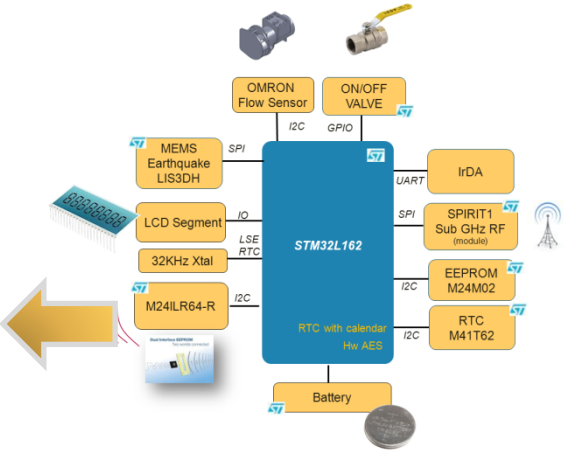
Battery 3.7V

Android Application is available to read/write gas mater parameter by RFID/NFC

GAS Meter – Evaluation Board







Application Notes
SPIRIT1 compliancy test reports

- **AN4110** EN 300 220 at 868 MHz
- **AN4174** ARIB STD-T67 standard in the 426 MHz band
- **AN4126** FCC title 47 part 15 in the 902 - 928 MHz band
- **AN4147** FCC title 47 part 15 in the 315 MHz band
- **AN4117** EN 300 220 at 434 MHz
- **AN4148** ARIB STD-T93 in the 315 MHz band
- **AN4133** ARIB STD-T108 in the 920 MHz band

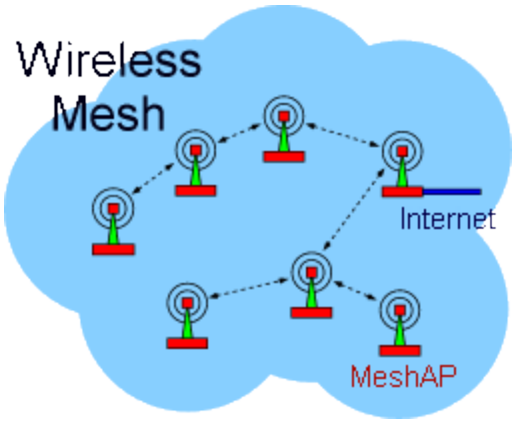
Thingsquare MIST Solutions

STM32L & SPIRIT1

life.augmented

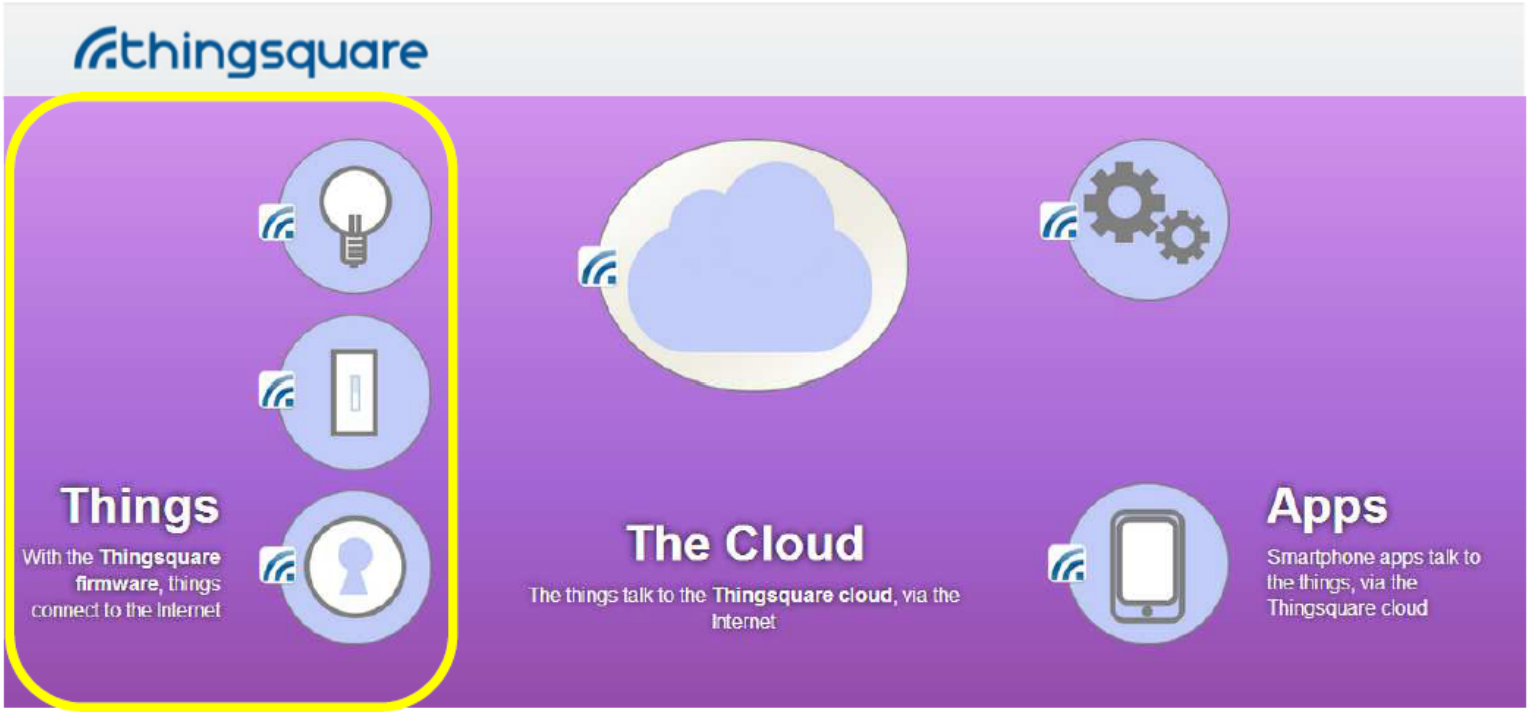
6LoWPAN and Internet of Things

- Spirit1 + STM32L based platform
  - Availability: March 2013
- Developed and provided by Thingsquare
  - A pioneering provider of open-source software
- To connect SPIRIT1 to Internet or any other IP network
  - Adapting the packet size of the two networks
  - Adaptation layer for interoperability and packet form
  - Mesh Routing in the personal area network
  - …
- Open source based on Contiki OS
  - Modest resources requirements
  - Over-the-air secure software updates

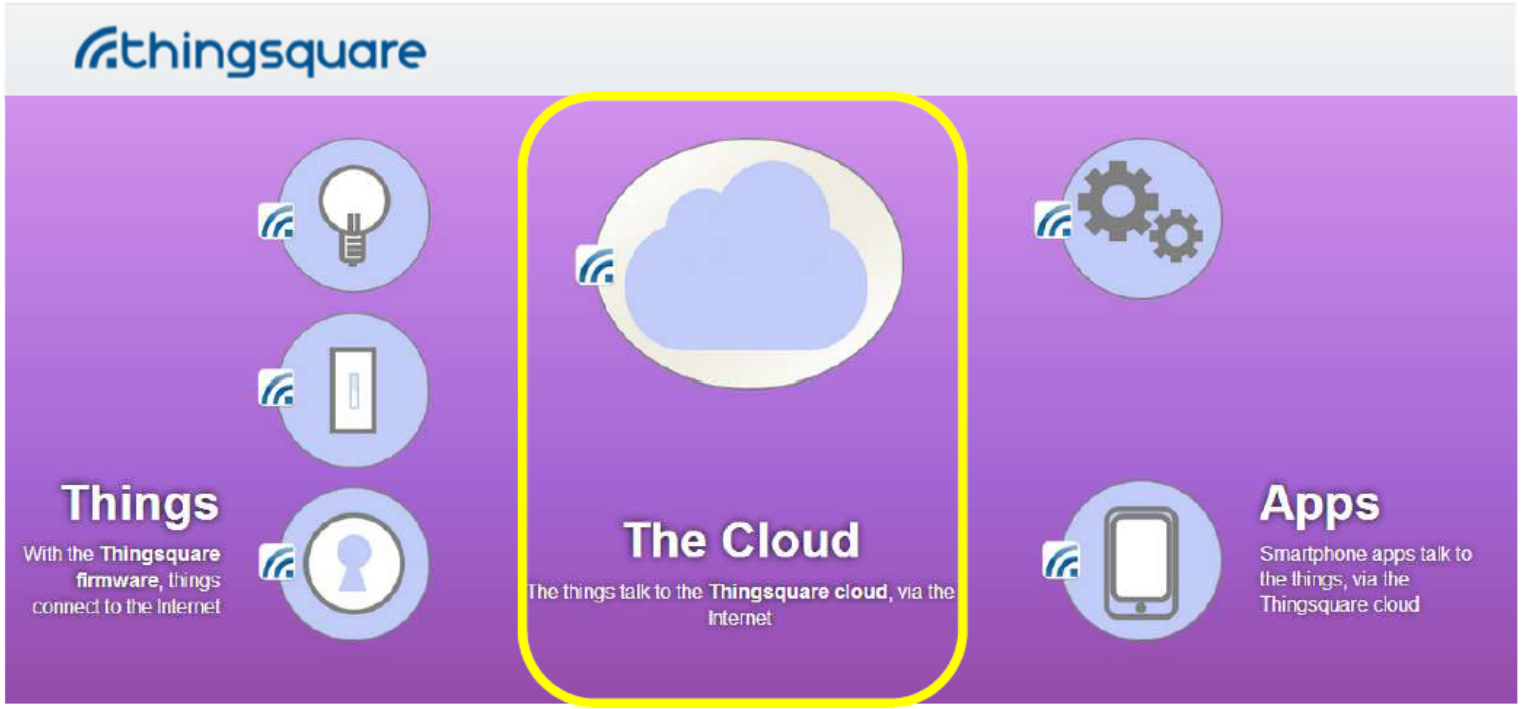


Enter Thingsquare

thingsquare
Things
With the Thingsquare firmware, things connect to the Internet
The Cloud
The things talk to the Thingsquare cloud, via the Internet
Apps
Smartphone apps talk to the things, via the Thingsquare cloud


thingsquare
Things
With the Thingsquare firmware, things connect to the Internet
The Cloud
The things talk to the Thingsquare cloud, via the Internet
Apps
Smartphone apps talk to the things, via the Thingsquare cloud

- Thingsquare Mist: the open source firmware that connects things to the Internet
  - Runs on SoCs, microcontrollers
  - Leverages the Contiki OS
  - IPv6 mesh + seamless IPv4 connectivity


thingsquare
Things
With the Thingsquare firmware, things connect to the Internet
The Cloud
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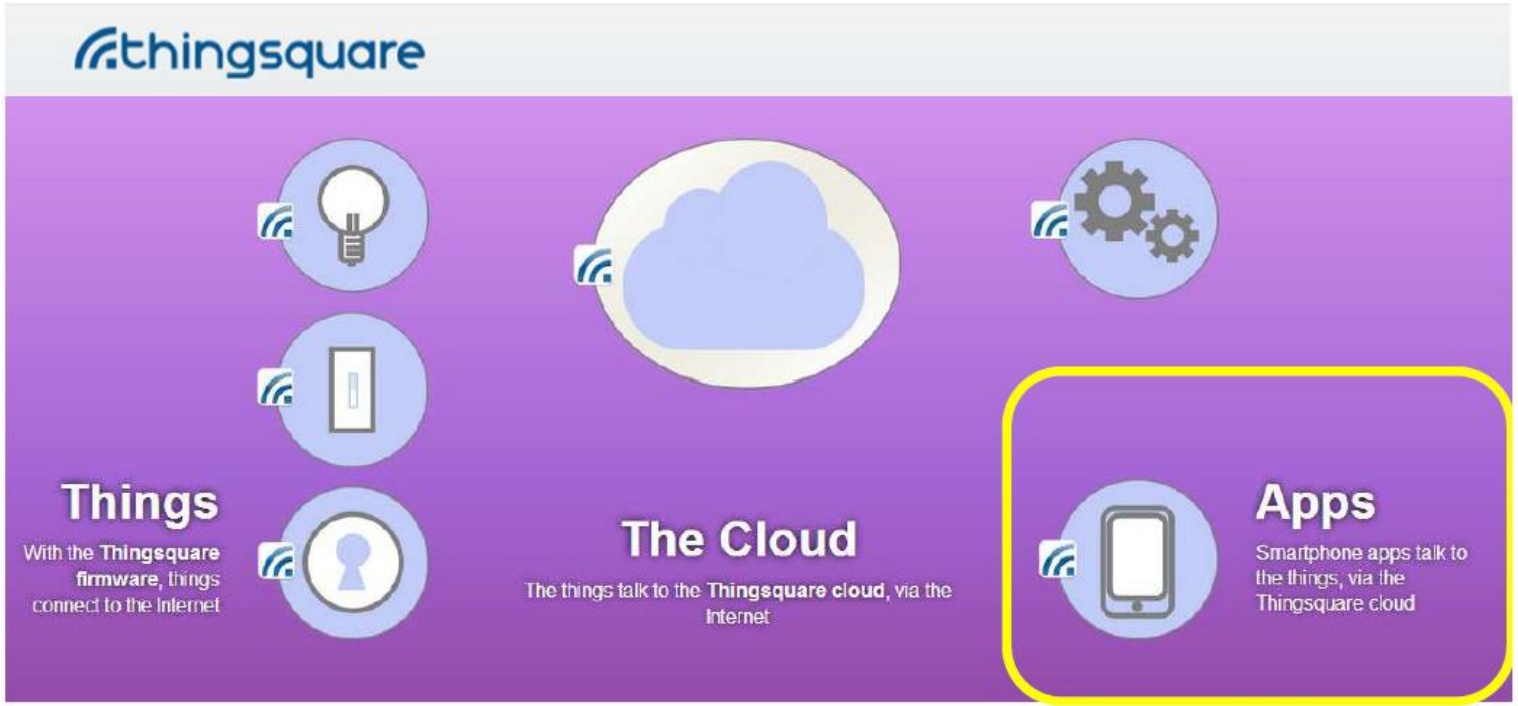
Apps
Smartphone apps talk to the things, via the Thingsquare cloud

- Thingsquare Cloud backend:
  - Rendezvous, pairing, monitoring, data collection


thingsquare
Things
With the Thingsquare firmware, things connect to the Internet
The Cloud
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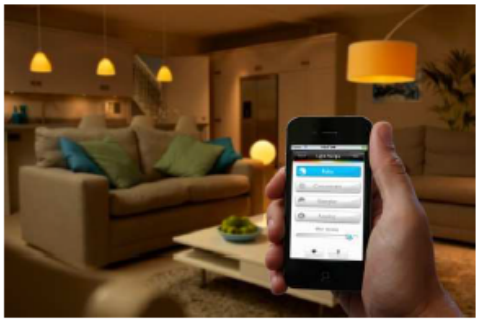
Apps
Smartphone apps talk to the things, via the Thingsquare cloud

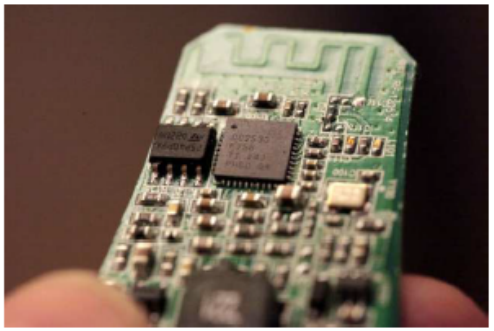
- Smartphone / web apps
  - Reaches the things via the Thingsquare cloud API

Building an IoT product

- The Idea
  - ”Everyone wants to have a smartphone-controlled lightbulb! I can sell millions of them!”
- What do you need?
  - An app
  - A chip

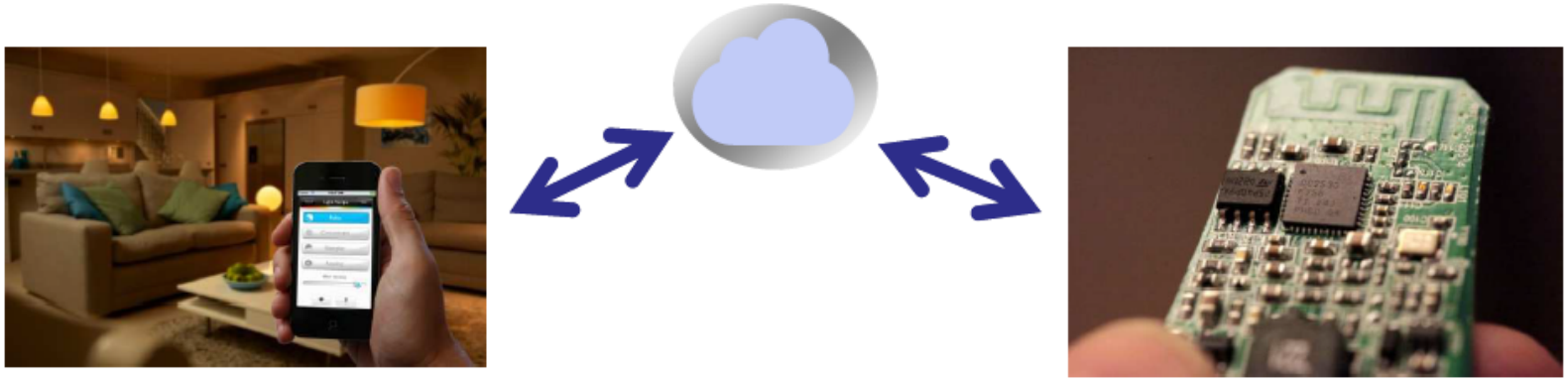
One possible solution





- Phone talks directly to chip
  - E.g. Bluetooth, BTLE, Ant+, ...
- The problem
  - Every user must configure their phone
  - Everyone must be in range
  - Chip must be compatible with *x* types of phones
    - Most of which don't have BTLE/Ant+/...

The IoT solution

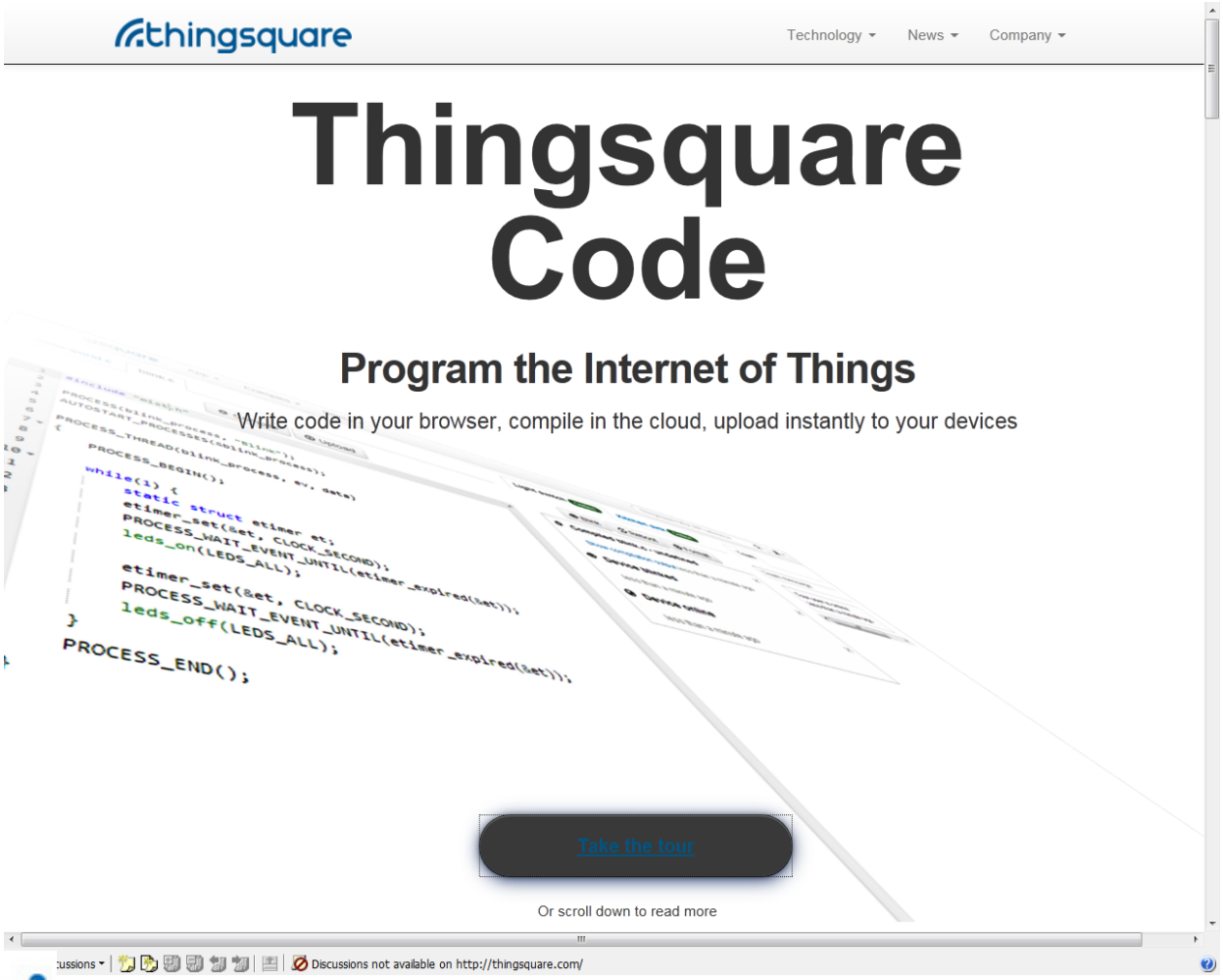


- Phone and chip talks to cloud backend
  - Works with every phone, easy to extend, remote connectivity, new innovations, etc
- The problem
  - Connect the chip to the Internet

Thingsquare Mist features

- World's smallest IPv6 stack
- The world's smallest IPv4/IPv6 router
  - NAT64 and DNS64
- AES encryption
  - Software, may use hardware accelleration
- Network sniffer
- Frequency hopping protocol
  - Needed for sub-GHz legal requirements
- Portable duty cycling (ContikiMAC, Drowsie)
- WebSocket protocol
- Nicer UDP and TCP socket APIs

Thingsquare Code



BALF-SPI-01D3

Companion chip to SPIRIT1 @ 868MHz

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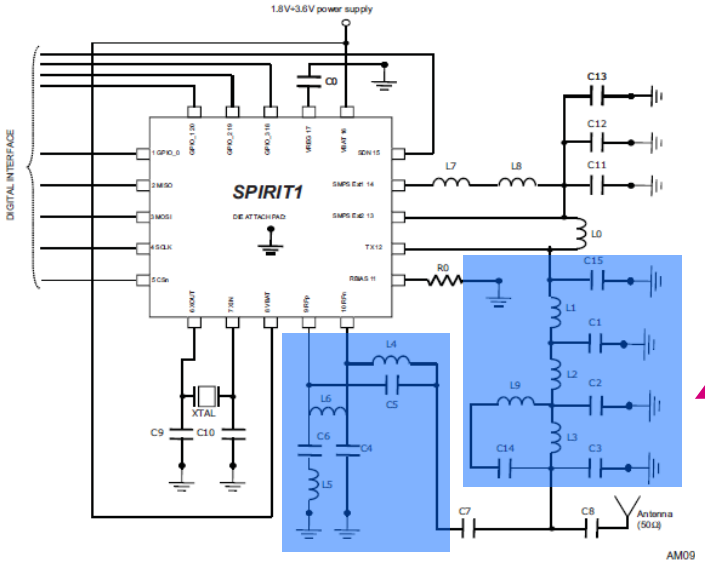
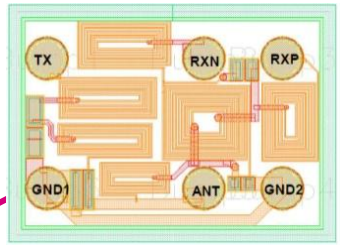
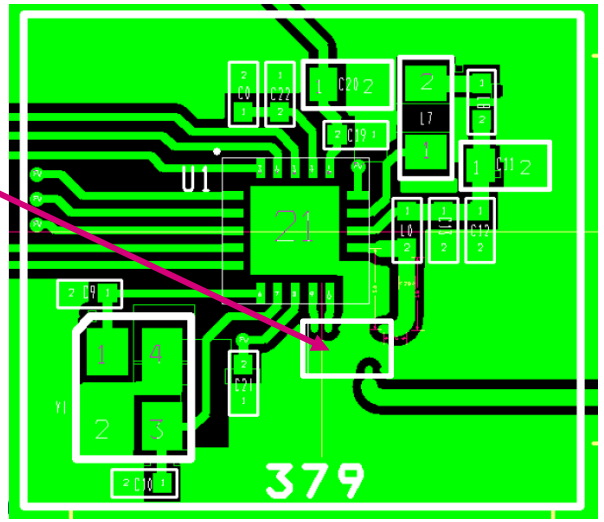
BALF-SPI-01D3

SPIRIT1 Companion chip





2.0 x 1.4 mm



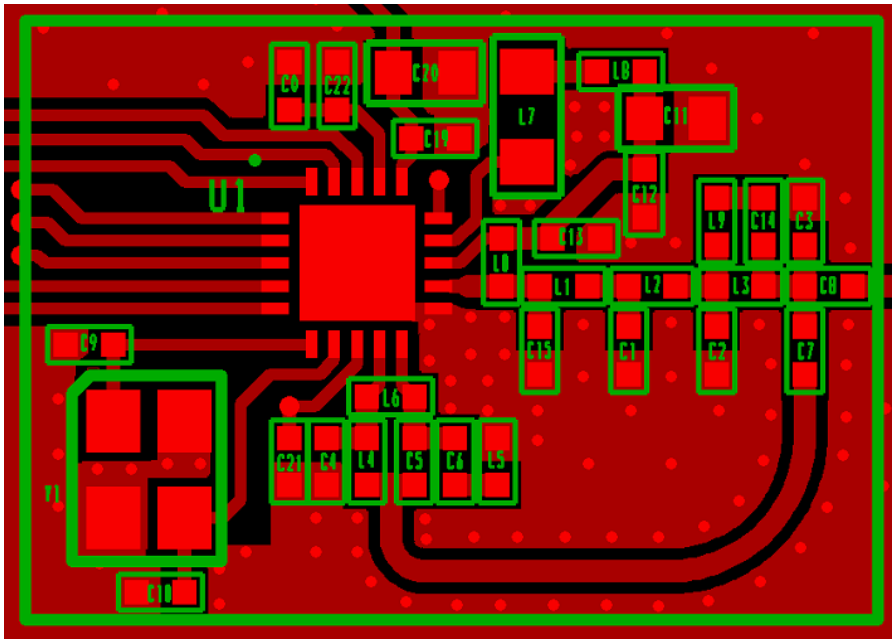
SPIRIT1 EVB with BALF-SPI-01D3

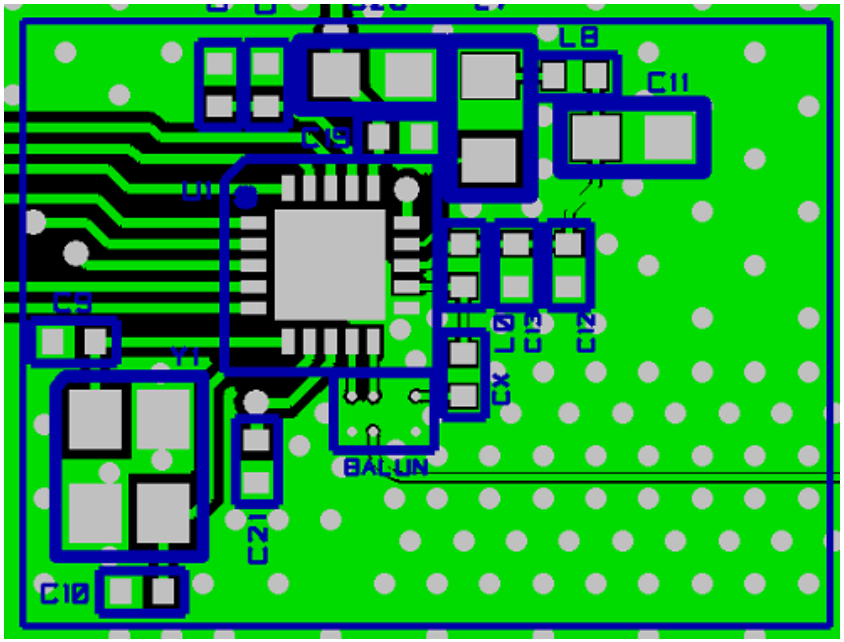
Sample : May 2013
Demo Board : May 2013
Ramp-up : July 2013

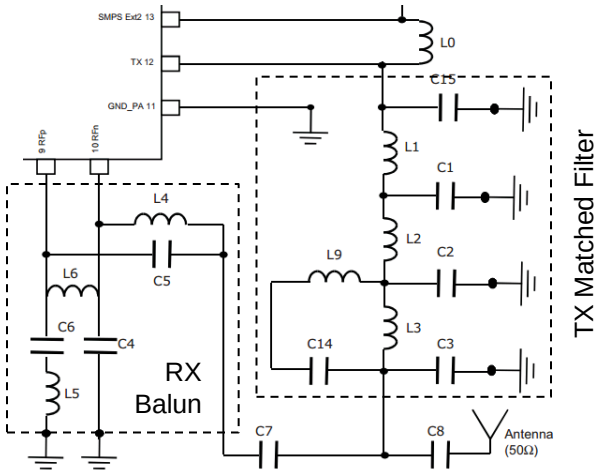
Balun+Filter into 1 die

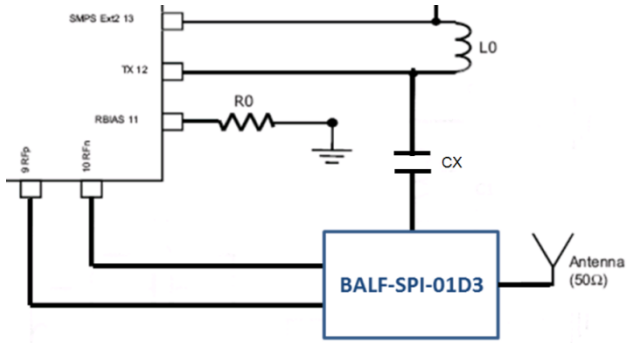
- ST IPD **Technology on Glass** : already used by main RF players
- Cover all ETSI, FCC & ARIB recommendation : **868 to 920 MHz** frequency range
- < 3mm² : Reduce **Size** (up to 70% vs discrete solution) and **Cost** (-60% from BOM+PCB)
- Dedicated companion chip : No validation needed at customer for **faster design** time
  - Validation on-going in **SPIRIT1** evaluation board
- No components dispersion or temperature variation : **Function is guaranteed**
- Integrated solution : Higher **Reliability**, better **Performance** (IL) thanks to low parasitic Glass wafer, greatly **reduce PCB sensibility**

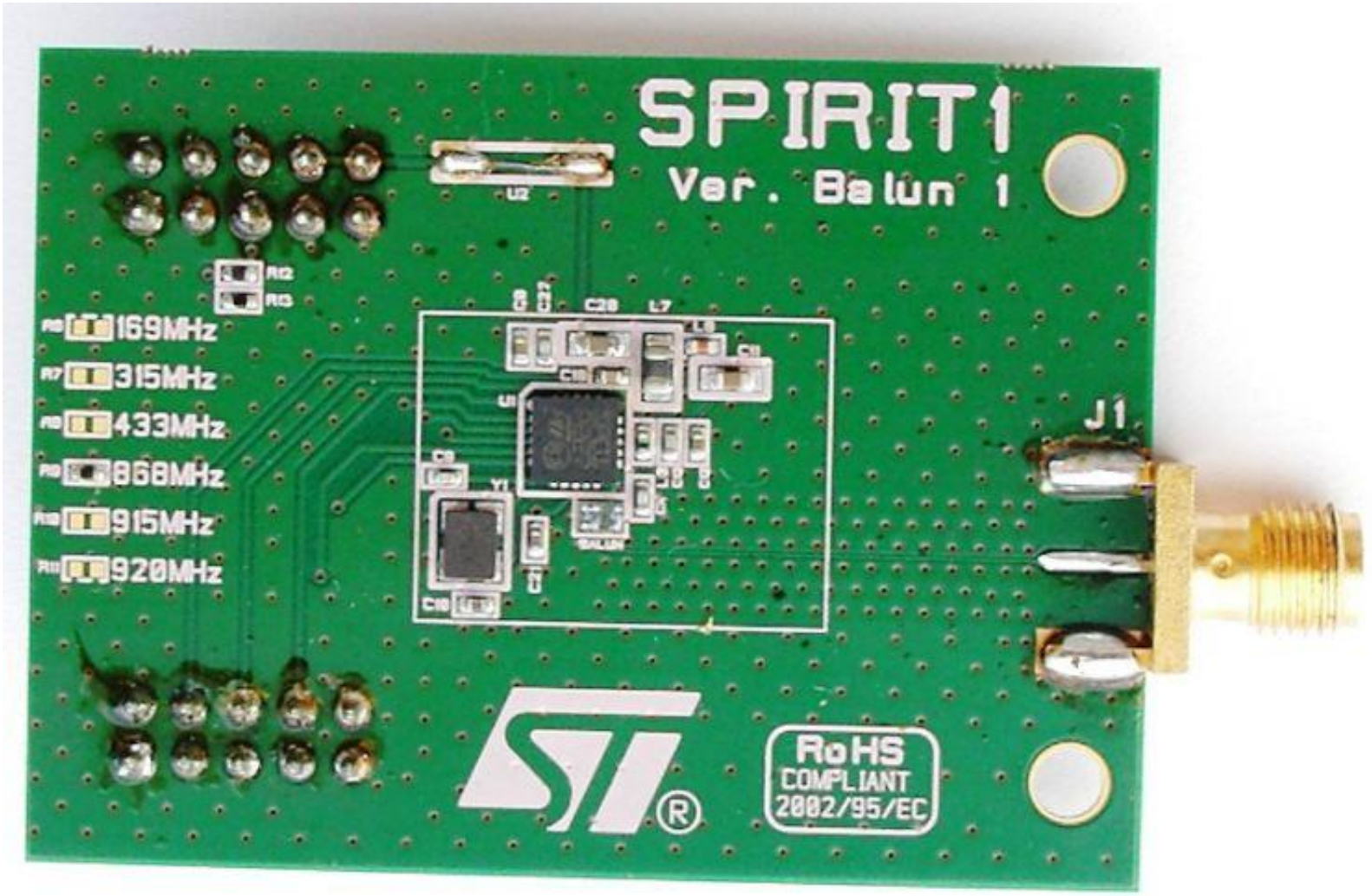
SPIRIT1
EVB Layout



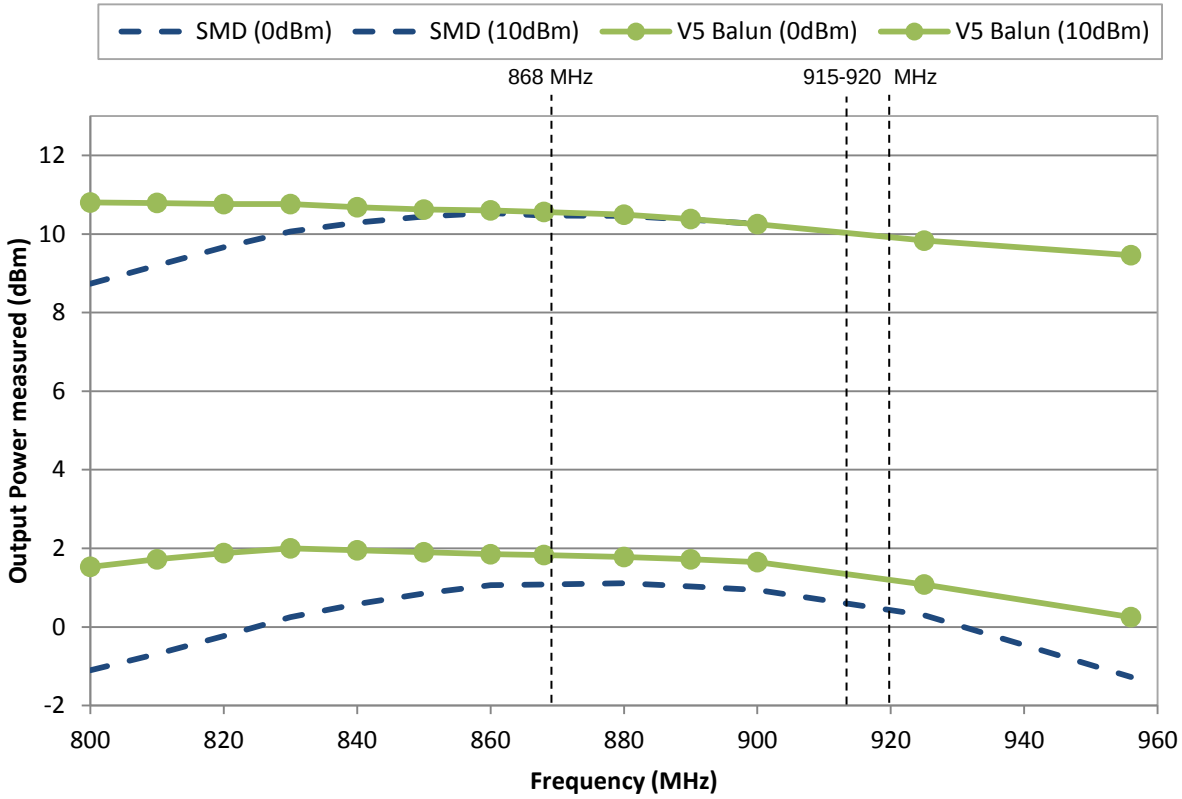






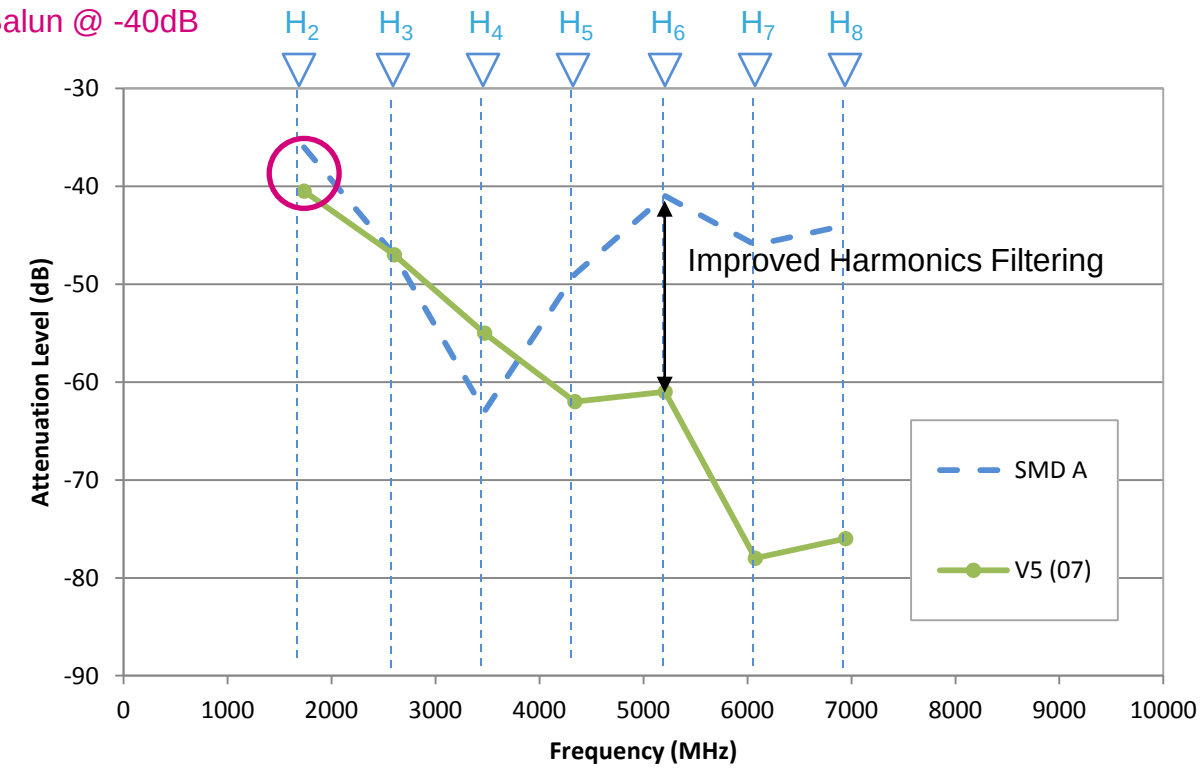

SPIRIT1
Ver. Balun 1
J1
169MHz
315MHz
433MHz
868MHz
915MHz
920MHz
RoHS
COMPLIANT
2002/95/EC

SPIRIT1 from 800MHz to 930MHz
Balun Flatness



SPIRIT1 @ 868MHz
Harmonics @ 10dBm

H2 SMD @ -36dB
H2 V5 Balun @ -40dB



THIN FILM IPD BALUN

Custom device for Texas Instrument CC25xx

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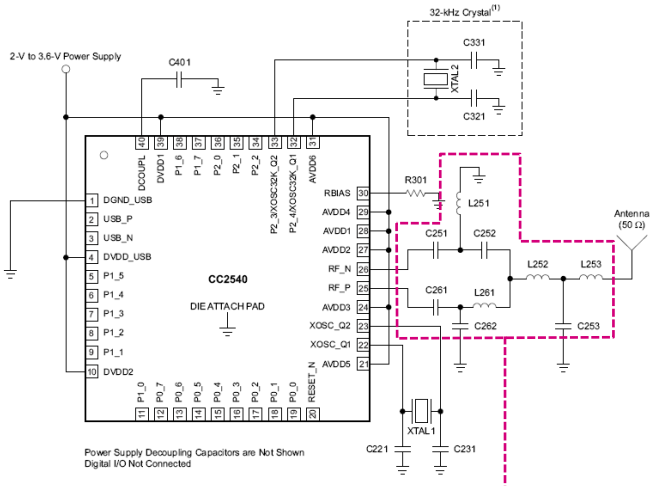
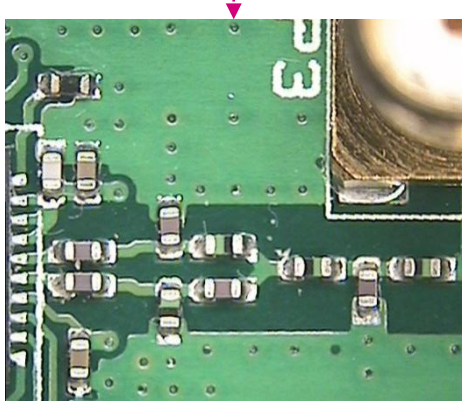
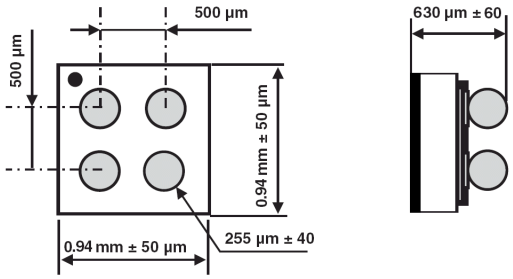
SMD vs. Thin Film IPD BALUN



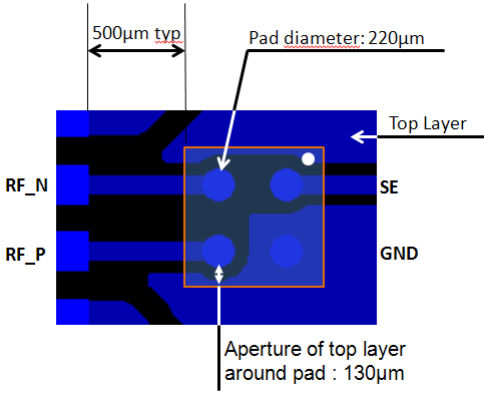


Passive integration

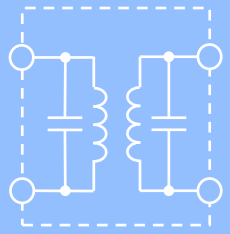
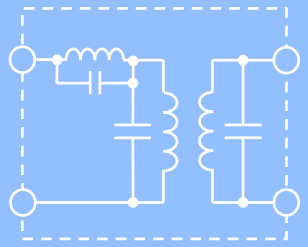


Flip chip

Smaller

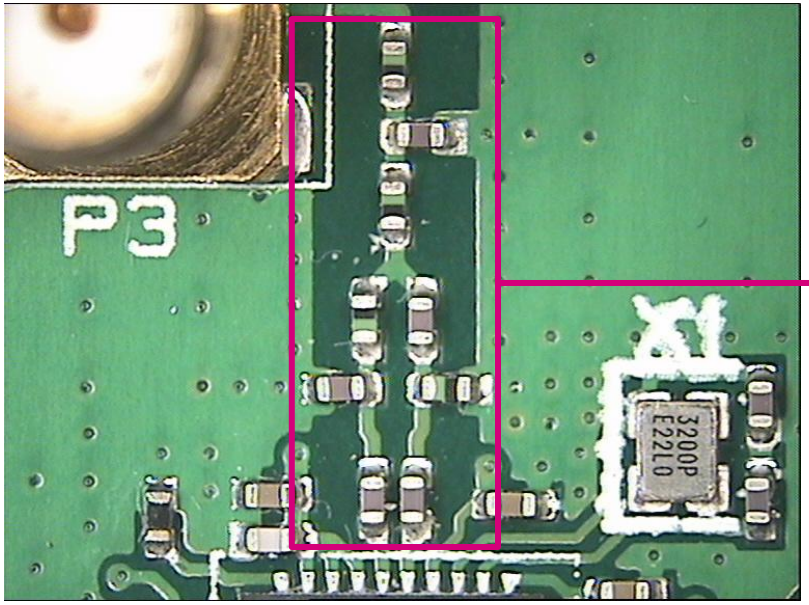


Texas Instrument
2.4 GHz Wireless radio

TI CHIPSET	APPLICATION	POSITIONING	ST BALUN PROPOSAL	DIFFERENTIAL LOAD IMPEDANCE
CC2530 CC2531 CC2533	ZigBee RF4CE	SOC RF + MCU	 BAL-CC25-01D3	69 + j 29 Ω
CC2540 CC2541 CC2541S CC2543 CC2544 CC2545	Bluetooth	BT LE + proprietary SOC		70 + j 30 Ω
CC2570 CC2571	ANT the power of less	ANT™ RF (no MCU) Network processors	 BAL-CC25-02D3	Same discrete network & values than CC2530
CC8520 CC8521 CC8530 CC8531	Wireless Audio	RF SOC + Audio + USB		70 + j 30 Ω

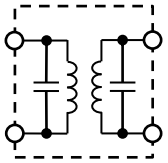
life.augmented | Компэл

Texas Instrument
2.4 GHz Antenna interface



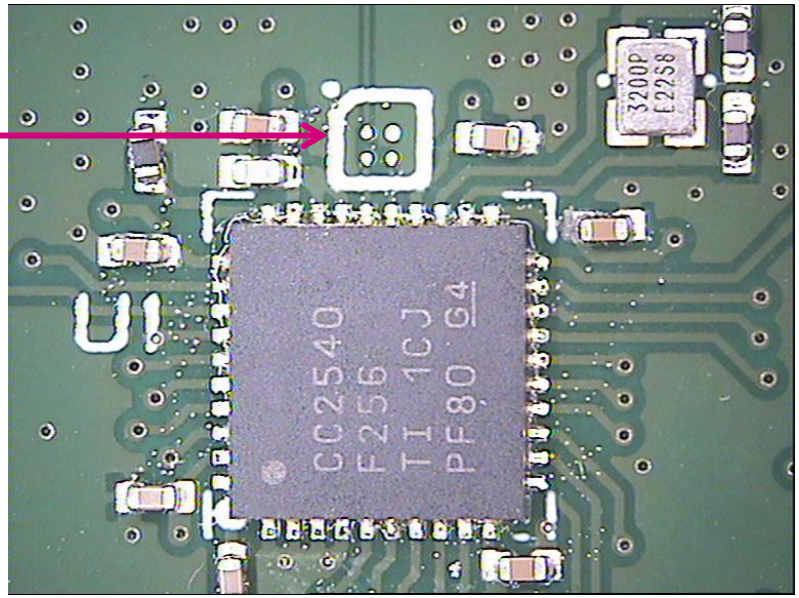
PCB layout with SMD components

- Component cout : **9 (0402)**
- solder joints : **18**
- Component tolerance : **±10%**
- **RF Performance** will vary as SMD tolerance can vary in opposite direction.
- **Reliability** & **assembly cost** direclty impacted by number of solder joints

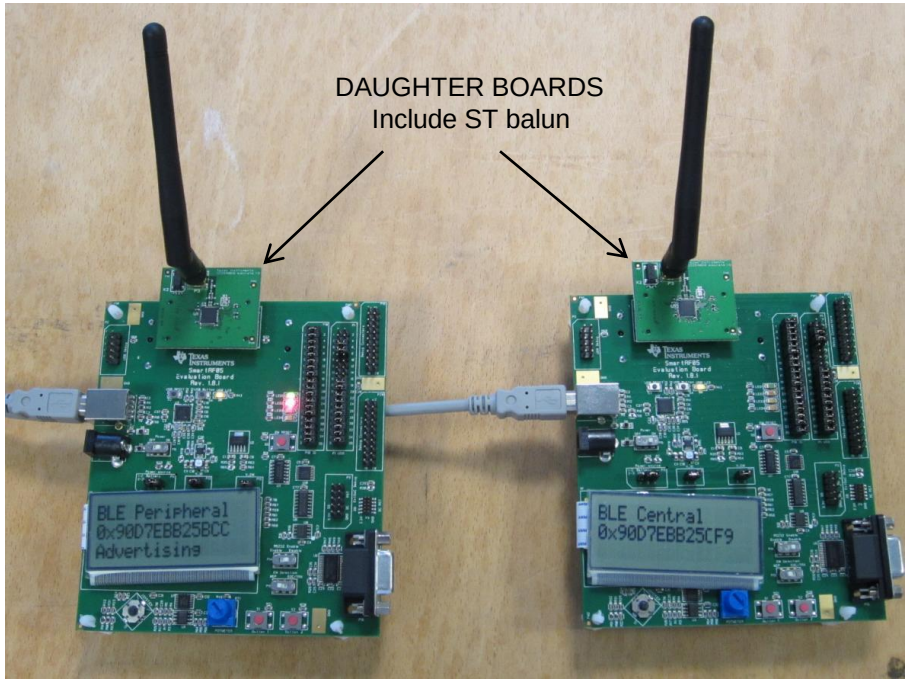


PCB layout with ST Balun

- Component cout : **1**
- solder joints : **4**
- Component tolerance : **NA**
- **Stable & Repeatable RF Performance** using custom impedance balun.
- **Better Reliability** & **lower assembly cost** thanks to Thin Film Semiconductor process



ST Balun Measurement on Texas Instrument daughter board



ST daughter board for
CC2540 / CC2544
with
BALCC25-01D3

ST daughter board for
CC2540 / CC2544
with
BALCC25-02D3

CC2544 performances summary with ST Balun

Texas instrument CC2544 (TX)		0 dBm		4 dBm	
Parameter	**Condition**	**BAL-CC25-01D3**	**BAL-CC25-02D3**	**BAL-CC25-01D3**	**BAL-CC25-02D3**
Output Power	2390 MHz	0.82 dBm	2.11 dBm	5.21 dBm	5.84 dBm
	2440 MHz	0.13 dBm	1.74 dBm	4.62 dBm	5.63 dBm
	2495 MHz	0.03 dBm	0.90 dBm	4.52 dBm	4.92 dBm
H2	4880 MHz span 400MHz	-51.3 dBm	-58.9 dBm	-47.2 dBm	-52.1 dBm
H3	7320 MHz span 400MHz	-46.6 dBm	-48.4 dBm	-38.7 dBm	-36.4 dBm
H4	9758 MHz span 400MHz	-57.9 dBm	-66.2 dBm	-52.4 dBm	-61.8 dBm

SPIRIT1 module

life.augmented

868 and 915MHz SPIRIT1 based module

- SPIRIT1 based Module

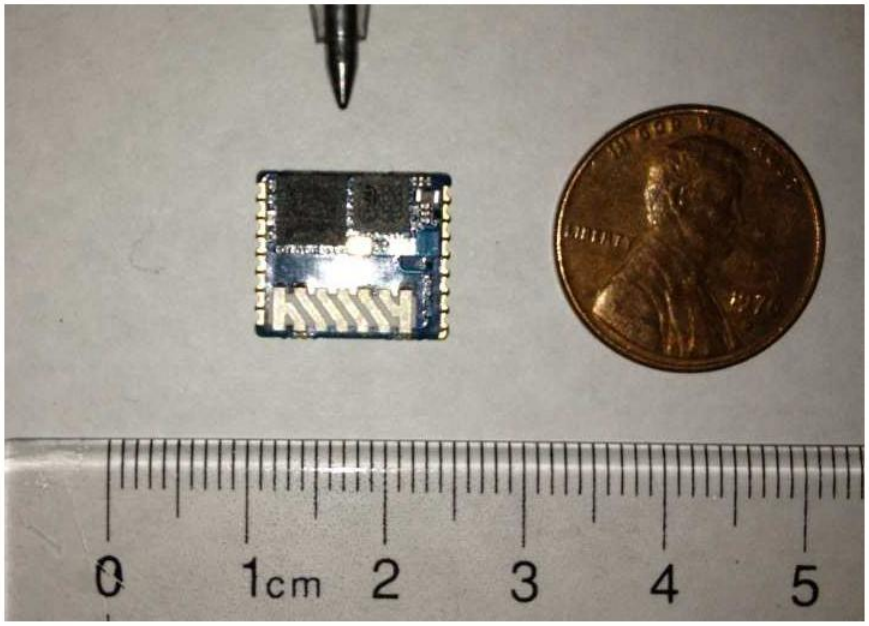
Supported bands 868MHz and 915MHz

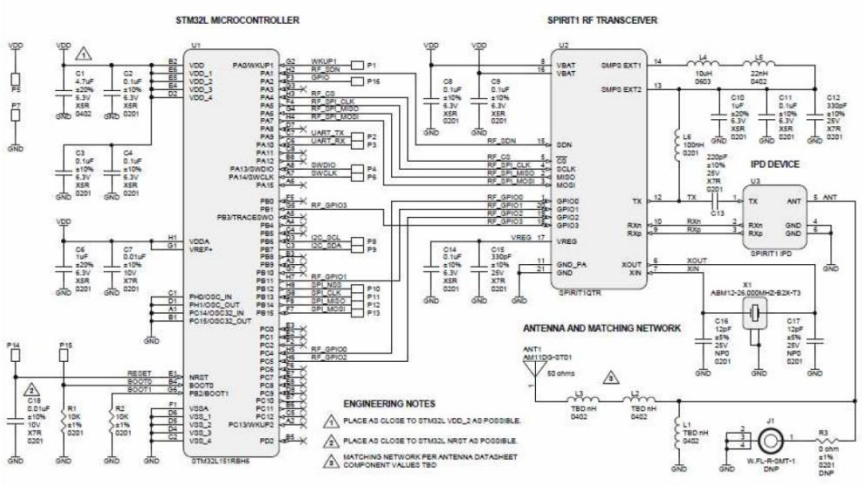
Using BALF-SPI-01D3 868/915MHz IPD balun and filter

STM32L151RBH6 MCU on board

Surface Mount antenna

AT Command set interface via UART





Thank you!